McKinsey Global Institute

The next big arenas of competition

Arenas are industries that transform the business landscape. Eighteen future arenas could reshape the global economy and generate $29 trillion to $48 trillion in revenues by 2040.

Authors
Chris Bradley
Michael Chui
Kevin Russell
Kweilin Ellingrud
Michael Birshan
Suhayl Chettih

Editor
Max Berley

Data visualization
Chuck Burke

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At a glance

- **Arenas are a unique category of industries defined by two characteristics: high growth and dynamism.** They capture an outsize share of the economy's growth, and the market shares of players within them change to an outsize degree.
- **We have identified 18 potential arenas of the future that could reshape the global economy, generating $29 trillion to $48 trillion in revenues by 2040.** These arenas range from AI software and services to cybersecurity, from future air mobility to drugs for obesity and related conditions, and from robotics to nonmedical biotechnology These future arenas could generate $2 trillion to $6 trillion in profit by 2040. Their collective share of global GDP could increase from 4 percent to 10 to 16 percent by 2040.
- **Twelve arenas of today showed outsize growth and dynamism from 2005 to 2020.** These industries include e-commerce, biopharma, electric vehicles, consumer internet, and cloud services. They had a revenue compound annual growth rate (CAGR) of 10 percent and market capitalization CAGR of 16 percent, and they tripled their global GDP share from 3 to 9 percent in the period. By contrast, non-arenas had only a 4 percent revenue CAGR and a 6 percent market cap CAGR over the same period.
- **The many striking differences between the 12 arenas of today and non-arenas inform our understanding of the arenas of the future.** Arenas earn far greater profits than other industries do, they spawn a disproportionate number of global giants, and they offer unusually strong opportunities for new entrants to become powerhouses.
- **Three combined ingredients in an "arena-creation potion" tend to generate the escalatory mode of competition that characterizes arenas.** The telltale elements of a forming arena are business model or technological step changes, escalatory investments, and a large and/or growing addressable market. The presence of these elements can lead to escalatory competition among players, who make large investments to gain not only market share but also a product quality edge, compounding the benefits and further setting them apart from other companies in a race to the top.

Introduction

This report from the McKinsey Global Institute identifies and describes a category of industries that could account for much of the future change in the business landscape and transform the world. We call these industries *arenas of competition*. To identify the arenas of tomorrow, we look back at the arenas of today to see how they evolved. Arenas are defined by two characteristics: they capture an outsize share of the economy's growth, and market share within them changes hands to an outsize degree. The presence of those two attributes indicates that a new competitive game has begun, usually prompted by a new bundle of technologies and business models.

Understanding arenas is important for at least two reasons. First, they are where the business world is reshaped. They account for many major shifts in investment, R&D, and value, as well as the emergence of many new and growing global corporations. Second, once we start to recognize the factors that could point to the potential formation of an arena, we can identify a set of arenas that could plausibly emerge over the next 15 years. If the past is any guide, they will be centers of competition, innovation, and value creation.

The report begins with a discussion of 12 arenas of competition that emerged between 2005 and 2020, including cloud services, e-commerce, biopharmaceuticals, and electric vehicles (EVs). Chapter 1 identifies the arenas of today by drawing on a large, customized data set of the top 3,000 companies by market cap and explores how the arenas differ from other industries. We used 2005 to 2020 as our analytical interval to delineate a clean decade boundary and ensure consistent, well-established data. Some of the differences are striking: in 2005, these arenas generated only 9 percent of our sample's economic profit, but by 2019 they accounted for 49 percent of all economic profit in the biggest companies.

In chapter 2, we examine how today's arenas emerged and grew as companies entered a mode of intense competition and made the escalatory investments characteristic of arenas. Understanding this industrial logic is crucial because knowing how today's arenas were born could help us spot tomorrow's potential arenas. We identified a "potion" that appears to underlie the emergence of arenas.

In chapter 3, we describe 18 potential arenas of tomorrow and explore how they may materialize, including their potential sources of growth and dynamism. Understanding potential arenas is relevant for entrepreneurs and incumbent companies that want to compete directly in arenas, other companies whose businesses would be affected by the emergence of arenas, investors looking to allocate capital to these industries, people seeking jobs in the winning industries of the coming decades, and policy makers looking to play a role in how and where these industries develop.

A compendium covering the 18 industries that could become the arenas of tomorrow includes further descriptions of the growth factors and competitive dynamics that we present in the report and that could shape each potential arena over the coming decades. To be sure, looking into the future is always speculative, and we recognize the possibility—indeed, the likelihood—that we may be getting some things wrong. For that reason, we have made transparent our assumptions, or what you need to believe about each candidate arena to match our scenarios. This will allow readers to calibrate their own views of which industries will end up becoming arenas.

Executive summary

This report identifies a set of present and future *arenas of competition*, industries that could transform the business landscape and our world. Arenas are defined by high growth and high dynamism. These industries capture an outsize share of value growth, and market share within them shifts dramatically, as measured by the "shuffle rate," a metric of company market share movements (Exhibit E1). These two characteristics signal a new era of competition and signify new technologies and business models in play.

The arenas of today

We have identified 12 arenas of today: software, semiconductors, consumer internet, e-commerce, consumer electronics, biopharmaceuticals, industrial electronics, payments, video and audio entertainment, cloud services, electric vehicles (EVs), and information-enabled business services (ranked in order of 2020 market cap). "Arenas of today" refers to the arenas that formed over the past two decades. We used 2005 to 2020 as our analytical interval to set a clean decade boundary and ensure consistent, well-established data. Understanding arenas is important for at least two reasons. Not only are they where the business world is reshaped, but recognizing the elements that are usually present in an arena and that help explain its growth and dynamism allows us to identify a set of arenas that could plausibly emerge over the next 15 years. If the past is any guide, they will be centers of competition, innovation, and value creation.

In 2005, arenas generated less than 10 percent of total global economic profit. By 2019, they accounted for half of the total.

Exhibit E1

The 12 arenas of today exhibited outsize shuffle rates and significant growth in share by market cap.

Market cap shuffle rates and growth share for 57 industries

Note: Based on McKinsey Industry Classification; Quality 4 & 5 data from McKinsey Value Intelligence, PitchBook only; subsidiaries excluded; includes only firms with market cap >$3.5B in 2005 or >$5B in 2020; number of firms by arena varies; firms identified as did not exist/nonpublic in '05 based on no McKinsey Value Intelligence market cap data in 2005.
Source: McKinsey Value Intelligence; McKinsey Global Institute analysis

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Today's arenas stand out from other industries in six ways.

— *Arenas captured an increasing share of economic profit.* In 2005, arenas generated $53 billion, or 9 percent of total global economic profit, while other industries generated $551 billion, 91 percent of the total. By 2019, arenas were generating $250 billion—half of total global economic profit. Comparing 2005 economic profit rankings with those from 2019 and 2020, every arena except industrial electronics moved up.

— *Arenas attracted outsize levels of investment for innovation.* Arenas' share of R&D investment was already high in 2005 and remained high for 15 years. Sixty-two percent of US business R&D spend went to arenas and arena-adjacent industries in 2005; that figure increased to 65 percent by 2020. Semiconductors and electrical components accounted for the largest share, followed by biopharmaceuticals and software.

— *Arenas enabled new entrants to grow.* In 2020, 34 percent of arenas' total market capitalization was held by companies that had been "outsiders" in 2005—that did not exist, had market caps of less than $3.5 billion, or existed but were not yet meaningful competitors in those arenas. In comparison, businesses new to non-arena industries held just 15 percent of total market cap. New players tended to enter during early stages of arena formation when competitors identified innovations that met customer demands as targets for investment. This competition led to arenas' characteristic dynamism.

— *Arenas spawned giants.* Arenas were more likely than non-arenas to give rise to the world's largest companies. In 2020, 74 percent of arenas' total market cap was held by companies with market caps greater than $50 billion, compared with 47 percent for other industries. 49 percent of arenas' total market cap was held by companies with market caps greater than $200 billion, compared with only 15 percent for other industries.

  Large companies were also more likely to be in arenas. Of the companies with market caps above $200 billion, half belonged to arenas, even though arenas represent only one-fifth of the overall sample by number of companies. In 2005, just one of the top ten companies was in a future arena—Microsoft, with a market cap of $278 billion. By 2020, eight of the ten were in arenas, with market caps ranging from $631 billion to $2.3 trillion.

— *Arenas tended to be more concentrated.* Concentration was observed at certain times in arenas; for example, the top ten players in four arenas (cloud services, consumer electronics, EVs, and payments) accounted for at least 90 percent of 2020 arena market cap and revenues in our sample. At the same time, competitive pressure to innovate remained. Investments that improve products or take advantage of network effects can have increasing returns, requiring leaders to continually innovate to retain prominence. Arenas' industry structures are rarely static or stable in the long term. Escalatory investments and their exceptional returns for arenas can inspire fierce competition in markets that already have high levels of innovation, provoking step changes in technology and business, which can disrupt the ranks of winners.

— *Arenas were more global.* On average, 50 percent of arena revenues were generated outside companies' home regions, compared with 42 percent for non-arena companies. Companies in arenas were also much more likely to be multinationals. Sixty-eight percent of arena companies derived more than 20 percent of their revenues from countries other than their own. By contrast, about half of non-arena companies took in more than 20 percent of revenues from other countries. The software arena is particularly global. Its four largest companies by 2020 revenues—Microsoft, IBM, Oracle, and SAP—generated almost 60 percent of their revenues outside their home countries.

The origins of arenas

To help us identify future potential arenas, we examined how today's arenas originated. We observed three elements that, when combined, were likely to result in high growth and high dynamism and to generate an arena. The three ingredients, which we call an "arena-creation potion," are business model or technology step changes, escalation incentives for investments, and a large or growing addressable market.

— *Business model or technology step changes.* Technology performance and adoption are often modeled as idealized S-curves. When a technology capability undergoes a step change, adoption starts off slowly, reaches an inflection point when it accelerates, then flattens out as the technology reaches maturity. Although real-world technology capabilities and adoption do not perfectly adhere to this S-curve, we observe technology step changes in our arenas, for example the innovations in lithium-ion battery technology that enabled production of EVs at scale. Business model step changes can also result from technology that shifts commercial models (who pays for what and how) for products or services, thereby disrupting existing market structures, as occurred with e-commerce and with video and audio entertainment (streaming).

— *Escalatory incentives for investments.* Companies that leverage investments to not only produce more products but fundamentally change and improve their products can boost their competitive position and rapidly gain market share. Such investments are features of specific types of spending, such as marketing, R&D, and certain capital expenditures. As companies advance their capabilities in this way, they tend to also improve long-term margins and see returns increase with scale. As a result, competitors also have a strong incentive to invest, beginning an "arms race" in which they iteratively invest to scale and scale to invest, causing a simultaneous escalation in capabilities. This pattern accelerates growth and the kind of market share jumps that are typical of arenas, and eventually can limit the ability for new entrants to enter the arena, unless a new technology or business model step change again opens up the playing field.

— *Large or growing addressable market.* Companies tend to reach large or fast-growing markets either by already playing in sizable markets where demand growth continues to outstrip the rest of the economy or by displacing share of an existing large market with a superior product or service. The companies in our arenas that played in fast-growing markets took advantage of technology and business model step changes to accelerate value creation. These markets typically already had revenue pools of more than $100 billion in 2005, and companies competing in them made escalatory investments that improved efficiencies or broadened capabilities. These arenas included biopharmaceuticals, industrial electronics, information-enabled business services, consumer electronics, payments, semiconductors, software, and video and audio entertainment. Together, they recorded 5 to 13 percent revenue compound annual growth rates (CAGRs) from 2005 to 2020. Companies that displaced share of existing large markets achieved rapid growth by launching novel categories of products or services, taking shares from existing markets or unlocking latent demand. These companies' industries include cloud services, consumer internet, e-commerce, and EVs. Their revenue grew at a 13 to 33 percent CAGR from 2005 to 2020.

The three ingredients of the arena-creation potion produce an escalatory mode of competition, which results in high growth and high dynamism. The continuous investments characteristic of escalatory competition typically build heightened competitive capabilities and globally relevant scale. Competition in these settings can be like a tournament with a huge prize to the winner, but it is not a lifelong crown, because a new round of competitive escalation often begins just as the last one is settling. This dynamic contrasts with more traditional modes of competition, which involve initial entry costs and additional investments to increase production quantity that result in more localized and

static industry structures. In escalatory competition, players must iteratively improve product quality through investment and capability building to obtain or retain market share.

In addition, the arenas of today generally benefited from the overall trend toward digitization. This last era of digitization was a fertile place for big arenas to bloom. Global internet connectivity allowed e-commerce players to connect buyers and sellers across the globe, providing the opportunity for customers to purchase goods anytime, anywhere. Digitization also transformed video and audio entertainment—and streaming video in particular—by shifting media consumption from movie theaters and CDs to homes and mobile devices.

Continual exponential improvements in the cost of processing and communicating information created a long S-curve. Digitization enabled global markets and scaled distribution platforms. Software-driven business models with low variable costs and strong network effects created a powerful battleground for escalatory investment. It is no surprise that most of today's arenas are rooted firmly in the digital economy.

The arenas of tomorrow

With these insights on existing arenas and their characteristics as a guide, we have identified 18 potential future arenas that together could yield $29 trillion to $48 trillion in revenues and $2 trillion to $6 trillion in profits by 2040 (Exhibit E2). In terms of impact on the economy, we estimate that they could grow from about 4 percent of GDP in 2022 to 10 to 16 percent by 2040. This translates to a 18 to 34 percent share of total GDP growth. This shift in GDP share is a hallmark of arenas: if we perform a similar analysis on our arenas of today, we find that the sample companies increased their equivalent share of GDP from 3 percent in 2005 to 9 percent in 2020.

Some arenas of today will continue as arenas of tomorrow. Others will no longer qualify for arena status.

Exhibit E2

The 18 potential arenas of tomorrow could generate $29 trillion to $48 trillion in revenues and $2 trillion to $6 trillion in profits.

18 potential arenas of tomorrow, by 2040 revenue estimate, $ billion	Revenue, 2022	2040 estimate	(CAGR, 2022–40, %)	Profit, 2040 estimate,[1] $ billion (profit margin, %)
E-commerce	4,000	14,000–20,000	(7–9)	280–1,000 (2–5)
AI software and services	85	1,500–4,600	(17–25)	230–920 (15–20)
Cloud services	220	1,600–3,400	(12–17)	160–510 (10–15)
Electric vehicles	450	2,500–3,200	(10–12)	100–320 (4–10)
Digital advertisements	520	2,100–2,900	(8–10)	320–580 (15–20)
Semiconductors	630	1,700–2,400	(6–8)	340–600 (20–25)
Shared autonomous vehicles	n/a	610–2,300		20–460 (4–20)
Space	300	960–1,600	(7–10)	50–160 (5–10)
Cybersecurity	160	590–1,200	(8–12)	90–240 (15–20)
Batteries	98	810–1,100	(12–14)	40–110 (5–10)
Modular construction	180	540–1,100	(6–10)	20–220 (4–20)
Streaming video	160	510–1,000	(6–11)	50–150 (10–15)
Video games	230	550–910	(5–8)	80–180 (15–20)
Robotics	21	190–910	(13–23)	20–180 (10–20)
Industrial and consumer biotech	140	340–900	(5–11)	10–270 (4–30)
Future air mobility	n/a	75–340		10–70 (10–20)
Drugs for obesity and related conditions	24	120–280	(9–15)	30–100 (25–35)
Nuclear fission power plants	18	65–150	(7–13)	5–50 (5–30)
Total	**7,250**	**29,000–48,000**	**(8–11)**	**1,900–6,100**

[1]Defined as net operating profit less adjusted taxes (NOPLAT). NOPLAT share based on most closely mappable industries from our database of 3,000 companies analyzed in chapters 1 and 2.
Source: Company annual reports; McKinsey Value Intelligence; McKinsey Global Institute analysis

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The potential future arenas can be divided into three groups: arenas of today that are likely to continue developing into arenas of tomorrow; subsegments of current arenas that may grow sufficiently large and fast to become spin-off arenas; and emergent arenas that are not as closely linked as the potential spin-offs to any of today's arenas. While at different stages of their evolution, each displays early signs of the three arena-creation potion elements.

Continuing arenas

1. *E-commerce.* Companies that sell goods through digital channels and fulfill them directly
2. *Electric vehicles.* Manufacturers of battery, plug-in hybrid, and fuel-cell EVs
3. *Cloud services.* Companies that deliver on-demand cloud infrastructure and platforms as a service
4. *Semiconductors.* Designers and manufacturers of semiconductors, microchips, and integrated circuits as well as providers of tools for semiconductor manufacturing

Spin-off arenas

5. *AI software and services (spin-off from software).* Companies that provide software and services incorporating AI, excluding the hardware necessary to operate AI
6. *Digital ads (spin-off from consumer internet).* Platforms that enable advertisers to reach consumers digitally
7. *Streaming (spin-off from video and audio entertainment).* Providers of on-demand video entertainment over the internet

Emergent arenas

8. *Shared autonomous vehicles.* Operators of shared autonomous vehicle services
9. *Space.* Providers of space-related infrastructure and services to the commercial and state-sponsored segments
10. *Cybersecurity.* Companies that provide protection for computer systems from unintended and unauthorized access, modification, or destruction
11. *Batteries.* Manufacturers of rechargeable batteries used for EVs and other technologies that are mostly linked to the energy transition
12. *Video games.* Producers and distributors of games played on dedicated consoles, PCs, and mobile phones
13. *Robotics.* Manufacturers of robots and providers of robotics solutions
14. *Industrial and consumer biotechnology.* Providers of biotechnology-enabled products in markets like agriculture, alternative proteins, biomaterials and biochemicals, and consumer products
15. *Modular construction.* Companies that operate in the modular construction value chain, from design to assembly, with volumetric modules
16. *Nuclear fission power plants.* Players that construct nuclear fission power-generation facilities
17. *Future air mobility.* Operators of air mobility transportation services, such as electric vertical takeoff and landing vehicles (eVTOLs) and delivery drones
18. *Drugs for obesity and related conditions.* Companies that sell glucagon-like peptide-1 (GLP-1) drugs and other treatments for obesity and related conditions, such as diabetes

Five arenas of today—biopharmaceuticals, consumer electronics, information-enabled business services, industrial electronics, and payments—could lose arena status. They are unlikely to maintain the scale of growth and dynamism that would propel them into being arenas of tomorrow.

We also examine almost-emergent arenas, industries with some elements that could make them arenas but that also have uncertain growth or dynamism prospects and a relatively lower probability of evolving into arenas. We include these because predicting the development of arenas is not an exact science, and we recognize that we could be wrong. These potential arenas could represent significant opportunities. The almost-emergent arenas include clean hydrogen, lower-carbon materials, products and services for older adults, nuclear fusion, renewables generation equipment and infrastructure, sustainable fuels, virtual reality and augmented reality, and Web3 (including decentralized finance).

Our analyses of present and future arenas reveal three key swing factors that go beyond uncertainties in the modeling and could be fundamental to the evolution of the arenas of tomorrow in technology, investment patterns, and sources of demand. These factors are developments in geopolitics affecting regulation of innovation and technological regionalization, advances and adoption of AI technology in a range of industries, and the pace of the green transition, which aims to alter the course of climate change and could drive demand in various parts of the market.

The 18 arenas of tomorrow we have identified could be even more materially transformative than the 12 arenas of today, shaping how we consume and process data, approach health and wellness, and interact and communicate with one another. They could introduce new options for our lives as well as new questions about our social progress, from the morality and ethics underpinning data and privacy to imperatives for businesses to be inclusive and sustainable. Recognizing how and when arenas originate, understanding how they evolve, and anticipating the way they could change society can offer a unique view of the arc of society's progress.

As we look forward, this report provides an initial view of where to expect the most growth and dynamism and how to update that view as the future takes shape. At the end of the report, we include a compendium that sketches the quantitative possibilities for the range of growth and the dynamism prospects of each of the 18 potential arenas of tomorrow.

CHAPTER ONE

The arenas of today

In 2005, there was no iPhone or App Store, no one had done a cloud migration, and a mass-market EV would have sounded like science fiction. Today, these technologies are commonplace, part of a wave of innovation that radically changed businesses, the economy, and the way we live. The economic growth from these innovations was concentrated in a relatively small number of industries.

The numbers tell the tale. Of the world's top 20 companies by market cap at the end of 2005, only four remain in the top 20 as of September 2024. The combined market cap of the top 20 grew more than sixfold from around $4 trillion at the end of 2005 to $25 trillion by September 2024. Of the new entries, almost all were in a handful of industries we have designated as arenas. This picture looks remarkably similar for the interval of 2005 to 2020, the period we study in detail. Of the world's 100 largest companies by market cap in 2005, only 46 remained on the list in 2020. Of the 54 newcomer companies, almost half were in a handful of industries we have designated as arenas, lifting the total number of top 100 companies in arenas from ten in 2005 to 33 in 2020. Arenas are defined by two characteristics: their revenues and market cap increase at a far faster pace than the rest of the economy, and shares of revenue and market cap within them shift substantially over time. We identified 12 arenas that formed during the 2005–20 period, ranging from cloud services to e-commerce to consumer internet to biopharmaceuticals, that have reshaped the business world.

Arenas also transformed our everyday lives, including the way we interact with one another, access information, complete tasks, entertain ourselves, and receive medical treatment. Take, for example, the simple experience of watching a movie with friends. In 2005, the process was straightforward: check schedules in the newspaper, call your friends, drive to the nearest theater or perhaps to the local video store in hopes that your DVD of choice is in stock. Today, a moviegoer would use their phone to check schedules online, decide if they want to buy a ticket in advance, message friends in a group chat, and proceed to the theater, perhaps in an EV hailed ride. Alternatively, you can decide to host a watch party, hop on a Zoom call, and stream a movie on Netflix. That activity alone involves a multitude of arenas, including semiconductors, software, and consumer electronics that enable mobile phone features; e-commerce, payments, and consumer internet, which allow the purchase of tickets online or buying streaming subscriptions; and EVs, industrial electronics, cloud services, and video and audio entertainment, which innovated ways of enjoying a service.

In this chapter, we describe the 12 arenas of today and explore how they differ from other industries.

Arenas are exceptional industries

For the purposes of this report, we have defined industries as groups of companies that compete for the same addressable market.[1] Because these companies sell similar products and target the same customers, their strategies inevitably overlap, making them both competitive and interdependent. Companies can be part of more than one industry when they sell products and services in more than one market.

Arenas are a unique set of industries in which the competitive tussle is heightened, resulting in the two characteristics we have identified: extraordinary growth and exceptional dynamism or shifts in shares. Players in arenas tend to innovate in technology and business models, invest at escalating levels in competitive capabilities, and expand possible addressable markets. Arenas show far greater levels of growth and dynamism than their non-arena peers because of these characteristics.

Industries can be analyzed on many levels. To identify potential arenas, we selected definitions based on supply and demand considerations. The supply perspective required some similarity in the technology of competing companies, as arenas are often launched through technology step changes. The demand perspective ensured that the products and services were sufficiently similar or substitutable and could define an addressable market. Together, these two criteria allowed us to define potential arenas at comprehensible levels of granularity (but we also recognize that these criteria are subjective, and alternative delineations are possible). In some cases, arenas were defined as a fast-growing portion of an existing industry. To name one such case, the automotive industry can be partitioned between internal combustion engine (ICE) vehicles and EVs. A similar pattern applies to other instances where a new arena forms adjacent to and draws demand from a large existing industry, as is the case with e-commerce and traditional retail, and biopharmaceuticals and traditional pharmaceuticals.[2]

The arenas of today were at different stages of development on different timelines and followed different trajectories in the 2005–20 time frame. It's easy to imagine the differing trajectories of the arenas of previous eras: oil and gas and mining, driven by rapid expansion of energy and materials needs; automobiles and commercial air travel, fueled by demand from a rising global middle class; and personal computers, powered by fast-growing new technologies, to name a few.

We suggest, however, that today's business landscape is influenced by the overlapping emergence of many big arenas. The common cause is the exponential force of digitization that has enabled both novel business models and rapid technological improvement on a global scale; we discuss these factors of critical importance later in this report.

Now we turn to the arenas of today to determine how they differ from other industries.

Today's 12 arenas grew quickly and were dynamic

To identify today's arenas, we relied on a McKinsey data set covering the world's 3,000 largest companies. For the purposes of our analysis, we reclassified some of them or parts of them from broad industry groups (such as retail) into more specific competitive categories (such as e-commerce). In some cases, this meant dividing a very large company (for example, Microsoft or Amazon) into two or three pieces, each in a different competitive category.

We then identified industries that exhibited outsize growth and market dynamism. Specifically, these industries grew quickly from 2005 to 2020, dramatically outpacing overall economic growth. That left them with a larger share of the world's revenues and market cap in 2020 than in 2005, a difference we call the "industry share growth rate." This metric captures the disproportionate value created in those industries. In addition, their dynamism, measured by company market share movements—a metric we call the "shuffle rate"—was relatively high during the period. In other words, there was more shifting of market share within the industries we selected to be arenas than in other industries (see sidebar "Industry dynamism measured by share shifts" and the technical appendix).

Sidebar: Industry dynamism measured by share shifts

To measure industry dynamism, we considered its degree of market share shifting by seeing how much either revenues or market cap changed hands among companies.

Consider some of the ten biggest players in the mobile and consumer electronics industry. In 2005, LG held 22 percent of market share by revenue in this group, but by 2020, its share had declined to 8 percent, a 14-percentage-point drop. Apple, by contrast, had a 5 percent market share by revenues in 2005. That had grown to 38 percent by 2020, an increase of 33 percentage points. Continuing this exercise for the entire market, we end up with market share percentage-point changes for each player. Adding up just the positive percentage-point changes gives us the industry's market shuffle rate as measured by revenues: 56 percentage points (Exhibit A). We applied the same process for both revenues and market cap to all companies, not just the top ten, in each industry in our analyzed data set.

Exhibit A

The top ten companies in the consumer electronics industry had a 56-point shuffle rate.

Company ranking by market share of revenue

Change in ranking 2005	Change in ranking 2020		Revenue share, % 2005	Revenue share, % 2020	Positive shifts, 2005–20
1	1	**Apple**	5	38	+33
2	2	Samsung	17	17	
3	3	**Huawei**	1	15	+14
4	4	LG	22	8	
5	5	**Xiaomi**	0	7	+7
6	6	Microsoft	14	5	
7	7	Sharp	13	4	
8	8	Sony	10	4	
9	9	**Lenovo**	0	1	+1
10	10	**Shenzhen Transsion**	0	1	+1

56
Percentage-point sum = shuffle rate

Source: McKinsey Value Intelligence; McKinsey Global Institute analysis

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Sidebar: Industry dynamism measured by share shifts (continued)

Now consider the top ten players in a different industry, aerospace and defense, which had notably less dynamism. Following the same approach, that industry had a 18 percentage-point shuffle rate, much lower than the shuffle rate of the mobile and consumer electronics industry (Exhibit B).

The shuffle rate indicates the degree of dynamism in an industry. We assumed that industries that had no revenues or market cap at the start of a period would necessarily have an aggregate share shift of 100 percent, as is the case with the nascent EV industry. Because high levels of dynamism were a criterion for qualifying as an arena, any nascent industry made the cut.

Exhibit B

The top ten companies in the aerospace and defense industry had an 18-point shuffle rate.

Company ranking by market share of revenue

	Revenue share, % 2005	Revenue share, % 2020	Positive shifts, 2005–20
Lockheed Martin	12	16	+4
Airbus	13	15	+2
Boeing	18	14	
Raytheon	14	14	
General Dynamics	7	9	+2
Northrop Grumman	10	9	
Honeywell	9	8	
BAE Systems	6	6	
Thales	0	5	+5
Safran	0	5	+5

18
Percentage-point sum = shuffle rate

Source: McKinsey Value Intelligence; McKinsey Global Institute analysis

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Our method for measuring industry-share growth rates and shuffle rates yielded rankings of industries by the extent of their growth and dynamism between 2005 and 2020—one set as measured by market cap (Exhibit 1) and another set as measured by revenues (Exhibit 2). We used a ranking system that considered both measures to settle on a single list of 12 arenas that placed high in combined ranking scores and had a 2020 market cap of at least $800 billion (for more information, see the technical appendix).

Exhibit 1

The 12 arenas of today exhibited outsize shuffle rates and significant growth in share by market cap.

Market cap shuffle rates and growth share for 57 industries

Note: Based on McKinsey Industry Classification; Quality 4 & 5 data from McKinsey Value Intelligence, PitchBook only; subsidiaries excluded; includes only firms with market cap >$3.5B in 2005 or >$5B in 2020; number of firms by arena varies; firms identified as did not exist/nonpublic in '05 based on no McKinsey Value Intelligence market cap data in 2005.
Source: McKinsey Value Intelligence; McKinsey Global Institute analysis

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Exhibit 2

The 12 arenas of today exhibited outsize shuffle rates and significant growth in share by revenue.

Revenue shuffle rates and growth share for 57 industries

Note: Based on McKinsey Industry Classification; Quality 4 & 5 data from McKinsey Value Intelligence, PitchBook only; subsidiaries excluded; includes only firms with market cap >$3.5B in 2005 or >$5B in 2020; number of firms by arena varies; firms identified as did not exist/nonpublic in '05 based on no McKinsey Value Intelligence market cap data in 2005.
Source: McKinsey Value Intelligence; McKinsey Global Institute analysis

Our arenas displayed outsize growth compared with other industries from 2005 to 2020. Arena revenues grew 10 percent year-on-year in that period, while revenues in other industries grew just 4 percent. The 12 arenas collectively more than doubled their share of revenue (from 6 percent in 2005 to 13 percent in 2020) and nearly tripled their share of our data set's total market cap (from 12 percent in 2005 to 34 percent in 2020). The biggest industry share shifts were in categories created by the new tech giants: cloud services, consumer internet, and e-commerce, driven by the growth of leading technology companies like Alphabet (Google), Amazon, Meta (Facebook), and Microsoft. For instance, e-commerce, which had the largest growth rate for revenues and second largest growth rate for market cap, accounted for only $15 billion of revenues in 2005, or 0.1 percent of revenues across all industries. By 2020, this number had grown to $874 billion, or 2.4 percent of revenues across all industries. In market cap, our e-commerce sample was an $87 billion industry in 2005, or

0.35 percent of market cap across all industries. That number grew to $3.2 trillion, or 4 percent of all industries, by 2020. Alibaba, Amazon, and JD.com contributed $547 billion, or 64 percent, of this revenue increase and $2.1 trillion, or 67 percent, of the market cap increase.[3] Similarly, consumer internet represented $215 billion in 2005, or 0.87 percent, of total market cap, which grew to $3.5 trillion in 2020, or 4.4 percent of market cap, in our data set. Alphabet, Meta, and Tencent were the largest players. Cloud services companies represented $10 billion in 2005, or 0.04 percent, of total market cap, which grew to $1.2 trillion and 1.5 percent of market cap by 2020, driven by growth of the cloud-services businesses of Amazon Web Services (AWS) and Microsoft.

These arenas similarly demonstrated exceptional competitive dynamism, measured by the shifts of revenue and market cap shares within an industry, or the shuffle rate. Average revenue shuffle rates for arenas were 50 percent, compared with 32 percent for other industries. Average market cap shuffle rates were 67 percent for arenas, compared with 47 percent for other industries.

Here we can see new industries transformed, as was the case with mobile and consumer electronics, in which the arrival of smartphones contributed to a large shift in the competitive landscape for players. Total industry revenues of $192 billion in 2005 were carved up as follows: LG had the highest revenues, $41 billion (22 percent of the total), followed by Samsung with $32 billion (17 percent) and Microsoft with $27 billion (14 percent). By 2020, total revenues had grown to $520 billion but had reshuffled, with smartphone players leading the way: Apple had revenues of $192 billion (38 percent of the total), and only Samsung continued to hold a top-three spot, with revenues of $88 billion (17 percent of the total). LG and Microsoft, which previously were in the top 3, now occupied the fourth and sixth spots, respectively.[4] Nokia occupied the fourth spot in 2005 with 13 percent of revenue market share, but by 2020, it held only a 0.3 percent revenue market share in this segment. There is also dynamism happening in these industries beyond just their players in 2005 and 2020. The iconic Blackberry brand was still relatively small in 2005, with roughly $2 billion in revenues. This grew quickly to almost $20 billion by 2010, but then fell again to under $2 billion by 2015.

A similar analysis yields the same results for market cap, with high shuffle rates between players. Together, these shifts put consumer electronics high on the reshuffling axis. Cloud services, e-commerce, and EVs also experienced this internal reshuffling, to a large extent due to the large market share movements of the players mentioned above (Exhibit 2).

The share shifts in market capitalization are also more volatile compared with revenues. For example, the semiconductors arena had the lowest market cap shuffle rate among arenas at 42 percent through 2020. By June 2024, its shuffle rate had more than doubled to 87 percent, driven by Nvidia market cap growth, effectively giving semiconductors the third-highest market cap shuffle rate among arenas. This dynamism, even in a short time, is typical of an arena. As we explain in chapter 3, semiconductors may continue as a future arena, driven by technological step changes such as the advances of artificial intelligence that can enable rapid reordering of companies in the race to the top.

Exhibit 3

Arenas exhibited exceptional growth in value creation and scale.

12 arenas of today, by 2020 market cap

	Companies, #	Market cap, $ billion		Revenue, $ billion	
		2005	2020	2005	2020
Software	110	291	3,951	70	349
Consumer internet	33	215	3,512	24	395
Semiconductors	79	642	3,427	194	574
E-commerce	74	87	3,160	15	874
Consumer electronics	17	342	2,448	192	520
Biopharma	92	416	2,430	57	343
Industrial electronics	111	395	2,006	389	987
Payments	24	68	1,712	34	146
Video and audio entertainment	36	265	1,453	149	424
Cloud services	21	10	1,171	2	102
Electric vehicles	16	1	1,033	—	101
Information-enabled business services	37	154	888	68	150
Total	650	2,886	**27,191**	1,194	**4,964**
Growth for arenas of today:		**9.4×**		**4.2×**	
Growth for all other industries:		**2.4×**		**1.7×**	

Note: Based on MIC (McKinsey Industry Classification); Quality 4 & 5 data from McKinsey Value Intelligence, PitchBook only; subsidiaries excluded; only firms with market cap >$3.5B in 2005 or >$5B in 2020 are included; # of firms by arena varies; firms identified as did not exist/non-public in '05 based on no market cap data in 2005 within McKinsey Value Intelligence.
Source: McKinsey Global Institute analysis

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Following is a brief description of the 12 arenas of today, ranked by their market cap in 2020.

Software. Companies such as Microsoft, Oracle, and Adobe that develop, maintain, and distribute software, increasingly as a service.

Semiconductors. Companies such as Intel, TSMC, and Nvidia that design and manufacture semiconductors. This arena also includes the providers of tools used to manufacture semiconductors, such as ASML.

Consumer internet. Companies such as Alphabet, Meta, and Tencent that provide consumers with internet services, including search, social media, and email.

E-commerce. Companies such as Amazon, JD.com, and Alibaba that only sell products online or provide online marketplaces. This arena also includes the divisions of traditional brick-and-mortar retailers that engage in online sales.

Mobile and other consumer electronics. Companies such as Apple and Samsung that engineer and manufacture personal mobile and other consumer electronics, such as smartphones, tablets, wearable devices, and televisions.

Biopharmaceuticals. Companies such as Amgen and Regeneron that develop and manufacture drugs based on biological materials like proteins and nucleic acids instead of producing traditional pharmaceuticals, which are typically drugs consisting of simpler chemical compounds. This arena also includes the biopharma segments of traditional pharma players, such as Pfizer and AstraZeneca.

Industrial electronics. Companies such as the contract manufacturers Foxconn, Jabil, and Flex that handle outsourced manufacturing for hardware designers (such as Foxconn for Apple). Also in this arena are original equipment manufacturers (OEMs) such as Panasonic, Siemens, and ABB that manufacture electrical equipment, testing devices, and components.

Payments. Companies such as Visa, Mastercard, and American Express that provide payment and transaction services like the networks that process credit-card payments.

Video and audio entertainment. Companies such as Paramount, Disney, and Netflix that provide video and entertainment via broadcasting, video streaming, and audio streaming, as well as record labels such as Warner Music.

Cloud services. Companies and their divisions such as AWS, Microsoft Azure, and Google Cloud Platform that provide IT infrastructure or platforms as online services, such as cloud computing and cloud storage.

Electric vehicles. Companies that manufacture EVs, ranging from those specializing only in EVs, such as BYD and Tesla, to the divisions of traditional automotive OEMs like Toyota, GM, and Mercedes-Benz, which have added EVs or plug-in hybrid EVs to their product lines.

Information-enabled business services. Professional services firms such as Deloitte; information, data processing, and analytics providers such as ADP and S&P; and consumer-credit-reporting agencies such as Experian, Equifax, and TransUnion.

Six key metrics that make today's arenas stand out

We highlighted six metrics in which the arenas of today outpaced other industries: share of economic profit, share of R&D growth, proportion of new entrants, proportion of companies with a market cap of more than $200 billion, proportion of market cap held by top ten players, and proportion of companies that generate at least 20 percent of revenues from outside their home country (Exhibit 4).

Exhibit 4

Arenas of today stood apart from non-arenas in terms of …

[1]We cite both 2019 and 2020, acknowledging 2020 was an exceptional year because of the COVID-19 pandemic.
Source: McKinsey Global Institute analysis

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Arenas capture an increasing share of economic profit. Today's arenas captured a much larger share of economic profit in 2019 than they did in 2005. Economic profit is what is left over after subtracting the cost of capital from net operating profit. Put differently, it is revenue minus the explicit costs of doing business and the implicit opportunity costs. In 2005, the industries that went on to become arenas generated $53 billion, or 9 percent of total economic profit in our data set, while the other industries we studied generated a combined 91 percent of the total, or $551 billion. By 2019, the arenas were generating $250 billion, or 49 percent of total economic profit. And in the exceptional

pandemic year of 2020, the economic profit of arenas continued to increase, while collectively, the economic profit of other industries was negative. Underpinning this increase is a persistently higher return on invested capital of 30 percent in the arenas and 10 percent outside of them (Exhibit 5). Comparing 2005 economic profit rankings with those for 2019, every arena other than industrial electronics moved up (Exhibit 6).[5]

Exhibit 5

Arenas' share of economic profit grew from 9 percent in 2005 to 49 percent in 2019.

Economic profit, $ billion

[1]Computed as net operating profit after tax/invested capital for a given year.
Source: McKinsey Value Intelligence; McKinsey Global Institute

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Exhibit 6

Arenas rose in rankings of economic profit.

Industry ranking by economic profit

Source: McKinsey Global Institute analysis

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In 2019, consumer electronics led the arenas in economic profit with $58 billion, followed by consumer internet with $48 billion and semiconductors with $45 billion. In 2020, the same three arenas were in the lead. Many developments—including rising global smartphone penetration, companies' widespread shift to cloud computing, and the increase in microchips embedded in a multitude of physical devices such as automobile components—boosted demand for the products in these arenas and fueled profits.

The decrease in economic profit among non-arena companies during the same period resulted from a number of factors, including a long-term decline of performance in commodity-driven energy and material sectors, lackluster performances by companies based in Europe, and lower profitability in the world's "next largest" companies (those that rank beneath the 500 largest companies by revenue).[6] The industries showing the biggest reduction in economic profit from 2005 to 2019 were oil and gas, which dropped $143 billion; retail and commercial banks, which fell $69 billion; non-bank financials, which dropped $58 billion; and mining, which fell $45 billion. The COVID-19 pandemic exacerbated these effects in 2020. Of course, these dynamics change with economic cycles, and some of the industries that trended downward from 2005 to 2020 may see a resurgence; for example, energy has experienced an upswing.

Arenas are where investment and innovation happen. Today's arenas received a disproportionate amount of R&D investment from 2005 to 2020. In the United States, 62 percent of all R&D spending was already allocated to arenas and arena-adjacent industries in 2005.[7] That share increased to 65 percent in 2020. Despite arenas' larger base, their R&D spending grew more than R&D spending in other industries over the same period (Exhibit 7). As a share of revenues, arenas also spent more

Exhibit 7

Arena companies account for a disproportionate amount of R&D spending in the US.

R&D spending among US companies, $ billion

Source: National Center for Science and Engineering Statistics and Census Bureau, Business Enterprise Research and Development Survey, 2005 and 2020; McKinsey Global Institute analysis

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on R&D: in 2020, 10 percent of the revenues of arenas and arena-adjacent industries went to R&D, compared to 5 percent for other industries.[8]

In data from the US National Center for Science and Engineering Statistics, semiconductors and electric components, pharmaceuticals, and software led in R&D spending. The semiconductor industry spent $43 billion on R&D in 2020, up from $19 billion in 2005. This increase reflected intense competition resulting from the disaggregation of the semiconductor value chain. Under the new model, companies made a series of competitive moves across the value chain, escalating investments in increasingly expensive efforts to stake out the technical frontier of one product segment or a single step of the value chain. Nvidia, for example, increased its annual R&D spending by a factor of 10 between 2005 and 2020 to become the leading player in the market for graphics processing units (GPUs).[9]

Pharmaceuticals spent an estimated $92 billion on R&D in 2020, up from $35 billion in 2005. This reflected the increase in pharmaceutical companies' average R&D spending as a percentage of revenues from about 17 percent in 2005 to 25 percent by 2020.[10] In addition, biopharmaceuticals R&D grew at a 14 percent average annual growth rate in the same period, compared with 4 percent for traditional pharmaceuticals. Software followed with an increase in R&D spending from $17 billion in 2005 to $35 billion in 2020.

Arenas attract "outsiders." Arenas are fertile ground for new entrants. In 2020, 34 percent of arenas' total market cap was held by companies that had been "outsiders" in 2005—that didn't exist, had market caps of less than $3.5 billion, or existed but were not yet meaningfully competing in those arenas. In other industries, just 15 percent of the total market cap in our data set in 2020 was held by businesses new to those industries. The entry of new players often happens during the early stages of arena formation, when competitors make investments as they discover which innovative products and services meet customer demand. Naturally, this means higher dynamism observed in arenas as competition plays out.

The consumer internet arena is a good example. About half of that industry's companies—including giants such as Meta, Meituan, and Shopify—either did not exist or did not report any public market cap in 2005.[11] That said, it would be wrong to think that only young companies belong in arenas. Microsoft and Apple are nearly half a century old.

Arenas spawn giants. Arenas are more likely than other industries to include the world's largest companies. In 2020, 74 percent of arenas' total market cap was held by companies with market caps greater than $50 billion, compared with 47 percent for other industries. Forty-nine percent of arenas' total market cap was held by companies with market caps greater than $200 billion, compared with only 15 percent for other industries (Exhibit 8). The same pattern is visible from a perspective of number of firms. In 2020, 15 percent of arena companies had market caps greater than $50 billion, compared with 8 percent of non-arena companies. Four percent of arena companies had market caps greater than $200 billion, while only 1 percent of non-arena companies met that benchmark.

Exhibit 8

Most of arenas' total market cap is held by 'giant companies.'

Distribution of market cap by company size, 2020

Note: Figures may not sum to 100%, because of rounding.
Source: McKinsey Value Intelligence; McKinsey Global Institute analysis

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While arenas are more likely to see most of their market cap driven by giant companies, it is also true that giant companies are more likely to be in arenas. Of the companies that have market caps above $200 billion, half belong to arenas, even though arenas represent only one-fifth of the overall sample by number of companies (Exhibit 9). In 2005, only one of the top ten companies was in a future arena—Microsoft, with a market cap of $278 billion. By 2020, eight of the ten were in arenas, with market caps ranging from $631 billion to $2.3 trillion.[12] The market cap lead was even more pronounced by 2024.

Exhibit 9

'Giant companies' are more likely to be in arenas than in non-arenas.

Distribution of 3,075 sample companies by market cap, 2020

Source: McKinsey Value Intelligence; McKinsey Global Institute analysis

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Information technology played an enormous role in the growth of arena giants. In 2005, the ten largest companies by market capitalization included several oil and gas firms as well as other well-known brands, such as GE and Walmart. By 2020, the top ten were led by tech companies: Alibaba, Alphabet, Amazon, Apple, Meta, Microsoft, and Tencent. By 2024, there was only one non-arena firm in the top ten.

Arenas tend to be more concentrated. Market cap and revenues are more concentrated in the largest arena companies than in non-arena companies. Consider the ten largest players in each of our arenas in 2020. The top ten in four arenas—cloud services, consumer electronics, EVs, and payments—accounted for at least 90 percent of market cap and revenues in our sample in 2020. Similarly, the top ten players in consumer internet, video and audio entertainment, and e-commerce had over 80 percent of both market cap and revenues in 2020. That is, more than half of the arenas met this 80 percent threshold. By comparison, only a quarter of non-arena companies met this cutoff for market cap and less than two-fifths did so for revenues.

But the industry structure is often not static or stable in the longer term. Even when arenas are concentrated, the competitive pressure to innovate persists, as investments that improve products or take advantage of network effects can have increasing returns, requiring the leaders to continually push to remain on top (discussed further in chapter 2). In the consumer internet arena, for instance, the three largest companies—Alphabet, Meta, and Tencent—accounted for 72 percent of market cap and 80 percent of revenues in 2020. In 2012, those same top three accounted for 73 percent of market cap. But from 2012 to 2020, intense competition shifted among the three companies, with Alphabet's share dropping from roughly 50 percent to 30 percent and both Meta and Tencent increasing from roughly 10 percent to 20 percent.

Furthermore, arenas are often markets with high levels of innovation, leading to step changes in technology and business models, which can disrupt the existing group of winners (see "Arenas are where investment and innovation happen" in this chapter). In some instances, the step changes also result in new spin-off arenas forming, which we explore in chapter 3. For example, the emergence of chatbots powered by generative AI (gen AI) threatens the advertising-supported web search business model, and platforms with short-form videos recommended by algorithms have grown quickly to capture user engagement in the social media space.

Arenas are more global. Arena companies tend to be more global than non-arena companies. On average, 50 percent of revenues in arenas were generated outside companies' home regions, compared with 42 percent for non-arena companies. Moreover, companies in arenas were much more likely to be multinationals.[13] Sixty-eight percent of companies from arenas derived more than 20 percent of their revenues from countries other than their own, compared with about half of companies in other industries.

Software is a particularly global arena. Fifty-three percent of its revenues came from outside its component companies' home regions in 2020. The four largest companies by 2020 revenues—Microsoft, IBM, Oracle, and SAP, which together accounted for more than half of the software industry's revenues—took in almost 60 percent of those revenues outside of their home countries. The global spread of these technology companies is unsurprising, given the digital nature of their products and services: they are not limited by shipping costs, physical plants, or input limitations, at least not directly (see sidebar "Companies based in the US and Greater China are disproportionately represented in arenas").

Sidebar: Companies based in the US and Greater China are disproportionately represented in arenas

Companies based in the United States were highly represented in arenas and accounted for a substantial majority, 66 percent, of 2020 market cap. US companies accounted for the majority of market cap in every arena except industrial electronics, where China took the lion's share. China also participated materially in the consumer internet, EVs, e-commerce, and semiconductors arenas, with 20 to 29 percent of market cap.

Companies based in Europe accounted for substantial market cap in biopharma, industrial electronics, and information-enabled business services. However, European companies had a much higher share of global market cap in non-arena industries (21.46 percent) than they did in arenas (9 percent) (exhibit).

Exhibit

The US and Greater China account for the majority of market cap across all arenas.

Regional distribution of market cap by arena, 2020,[1] %

[1]Companies' regions defined by their country of incorporation.
Source: McKinsey Value Intelligence; McKinsey Global Institute analysis

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Four side-by-side examples

Some arenas are carved out of large established industries that don't exhibit outsize growth and dynamism. This gives us a natural set of comparable examples of traditional industries and arenas to illustrate these differences. We describe four of them below: payments and banking, biopharma and pharmaceuticals, EVs and traditional ICE vehicles, and e-commerce and brick-and-mortar retail (Exhibit 10). The four relatively new industries are examples of arenas that have sufficiently novel technologies or business models to merit separating them from the industries they disrupted during this period.

Exhibit 10

Our sample arenas surpassed their traditional counterparts in economic growth, market concentration, and opportunities for new entrants.

Comparison of 4 arenas and their traditional counterpart industries

[1]Defined as non-incumbents from 2005 (ie, firms that didn't exist, had market cap of less than $3.5 billion, or existed but were not yet meaningfully competing in those arenas).
[2]From $0 in 2005 to $46 billion in 2020.
Source: McKinsey Value Intelligence; McKinsey Global Institute analysis

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Consider how the payments industry, which is one of the arenas of today, compares with the closely related banking industry, which is not an arena. Banking showed economic profit of $88 billion in 2005, but by 2019, economic profit had shrunk to $19 billion. During the same period, economic profit in the payments industry rose from $4 billion to $17 billion. Payments was also far more concentrated than banking: the top five companies in payments held 75 percent of market cap in our data set in 2020, while the top five in banking held 18 percent. Also in 2020, new businesses held 32 percent of all market cap in payments; in banking, the share was just 3 percent.

Or compare the biopharmaceuticals arena with traditional pharmaceuticals. Economic profit in this arena increased more than sevenfold, from $6 billion in 2005 to $42 billion in 2019. By contrast, economic profit in traditional pharmaceuticals increased by only 10 percent, from $42 billion in 2005 to $46 billion in 2019. The biopharmaceuticals industry also offered more opportunities to new entrants, which had 33 percent of market cap in 2020—a much larger share than the 15 percent new businesses held in traditional pharmaceuticals.

And consider the EV industry alongside the traditional auto industry. In 2005, the fledgling EV industry had very few players, but by 2020, it received all of its $101 billion in revenues from new businesses. It was also highly concentrated: the five largest EV players accounted for 87 percent of market cap, far more than the 28 percent share held by the five largest traditional auto companies.

Finally, consider the e-commerce and retail industries. Between 2005 and 2019, e-commerce's economic profit grew from $1.1 billion to $5.6 billion, compared with retail's growth from $20 billion to $32 billion. E-commerce also experienced explosive growth during the COVID-19 crisis, generating $13 billion in economic profit in 2020. In 2020, the five biggest e-commerce companies held 70 percent of the industry's market cap, and new businesses represented 57 percent. In retail, the five biggest companies accounted for just 42 percent of market cap, and new businesses had only 11 percent.

▪ ▪ ▪

In this chapter, we identified industries that became arenas from 2005 to 2020, and we explored the ways in which they differed from other industries. We have shown that arenas outperform their counterparts in R&D investment inflow and value creation, provide more opportunity to new entrants, and tend to become more concentrated. In chapter 2, we examine how the arenas of the present emerged and grew from 2005 to 2020 and discuss how that understanding can help us spot the emergence of the arenas of tomorrow.

CHAPTER TWO

The arena-creation potion

To understand how our present-day arenas came into being, we need to take a time machine to go back about two decades. What would we have seen? Let's look at four industries that became arenas from the early to mid-2000s.

In 2005, e-commerce had a market cap in our data set of only $87 billion. The industry reported revenues of $15 billion, accounting for only 2.5 percent of overall US retail sales. Amazon had recorded rapid revenue growth, from $16 million in 1996 to $8.5 billion in 2005. It was investing in its merchant network, started in 2000, and in its fulfillment services, launched in 2006. At the same time, the world was becoming more digital, as US internet penetration increased from 9 percent in 1995 to 68 percent in 2005.[14] Other players were also making moves: eBay acquired PayPal in 2002, and Shopify launched its alternative to the Amazon ecosystem in 2006. By 2020, e-commerce had a market cap of $3.2 trillion and revenues of $874 billion in our data set.[15]

The video and audio entertainment industry, which had a market cap of $265 billion in 2005, also began to transform. At the beginning of this period, content producers, such as Disney and Paramount, distributed their productions through traditional movie theaters and through DVD rentals offered by the likes of Blockbuster and Netflix, as well as broadcast and cable TV. The subscription model began to emerge in 2003, when Netflix filed a patent for subscription rental services for physical DVDs. In the next few years, the company grappled with Blockbuster over pricing and delivery models. The Netflix subscriber base continued to grow, from 1.4 million in 2003 to 7.3 million in 2007. Revenues grew, too, from $272 million in 2003 to $1.2 billion in 2007.[16] In 2007, Netflix launched online streaming, now its primary business model. By 2020, the video and audio entertainment industry's market cap reached $1.5 trillion.

In 2005, the semiconductor industry's market cap was just $642 billion. That year, Intel launched its first multicore processor, and in 2006, it announced the construction of a production facility in Vietnam, its biggest to date. Today's widely used Intel Core i7 processor debuted in 2008. Meanwhile, the semiconductor manufacturer TSMC started to strengthen its leadership in the foundry segment. From 2000 to 2005, the company had started production in four new fabrication plants, with an associated initial investment of about $14 billion. TSMC started to spend 20 percent more on R&D than its three biggest competitors combined in 2008. By 2020, the semiconductor industry was a $3.4 trillion arena by market cap.

The EV industry also started to coalesce into an arena in the early 2000s. The first modern lithium-ion batteries were commercialized in the early 1990s in Japan, and by the early 2000s, battery packs capable of powering a car were assembled. Honda and Toyota entered the hybrid EV market in this period. Tesla began development of its Roadster in 2004. It launched in 2008 and was the first pure EV, with a range of more than 240 miles per charge. By 2020, the EV industry had a market cap of $1.0 trillion.

In the early 2000s, perfectly predicting the path of these four industries would have been an impossible task. In hindsight, we observed interesting developments related to growth, investment, and new competitors happening in these arenas. How did the primordial ooze of these early indicators bubble up into an arena?

In this chapter, we describe the inner processes transforming industries into arenas that generate growth and dynamism and examine how those characteristics manifested themselves in the 12 arenas of today.

The arena-creation potion and escalatory competition

What are the elements that give rise to an industry that displays high growth and high dynamism? We have identified three that, when combined, become what we call an "arena-creation potion." The three ingredients are: technology or business model step changes, an escalation mechanism for investments, and a large or growing addressable market (which investors often refer to as the total addressable market, or TAM).

The three ingredients emerge in a certain order. We observed that arena formation starts with a technology or business model step change that encourages players to invest rapidly in quality. These escalating investments constitute the second ingredient. The players then undertake the cycle of continual investment to tap a large or growing addressable market. However, while there is a causal order to the three ingredients, there is also an unpredictable element of time as players churn, invest, and innovate until the latent demand of a large TAM is unlocked and an arena is formed.

Technology and business model step changes

The first potion ingredient is a technology or business model step change that fundamentally transforms how products and services are developed or delivered. Performance for a given technology (for example, how many transistors can fit into a square centimeter of silicon, or how much energy per kilogram can be stored in a battery) and adoption of a technology (what percentage of a given market is using that technology) are often modeled as idealized S-curves. When a technology capability undergoes a step change, adoption starts off slowly, reaches an inflection point when it accelerates, then begins to plateau as the technology or business model reaches maturity. At the top of the S-curve, the competitive game tends to settle into mature markets competition (contests with a few large competitors and relatively high barriers to entry), but the intensity of competition among them can persist, as we describe later in this chapter.

In practice, technology capabilities and adoption don't always follow this idealized S-curve form perfectly, but the conceptual pattern is a useful framework. We observe technology step changes in our arenas when a technology innovation is of a substantial magnitude and puts the trajectory of performance on a new S-curve, as we saw with EVs.

We also observed step changes in business models in our arenas. These were often enabled by technology and caused by innovations that shift the commercial models (in other words, who pays for what and how) related to products or services, disrupting existing market structures, as with e-commerce and video and audio entertainment (streaming). You could also think of the adoption of business model innovations as following S-curves.

In the semiconductor industry, we saw both technology and business model step changes. This industry regularly sees technology step changes in the form of "node resets"—broadly, the process of building new generations of semiconductors with smaller transistors and other components. Over the first two decades of the 2000s, semiconductor technology jumped to smaller and smaller node sizes, effectively resetting the technology curve about every five years, in line with the exponential increase in the number of transistors per integrated circuit predicted by Moore's law.

These regular industry-wide shifts to smaller and smaller node sizes caused the markets for larger node sizes to decline over time. In 2000, production spanned the 0.13-to-0.5-micron (130-to-500-nanometer) range. In just ten years, only a small segment of the market was producing chips with nodes larger than 90 nanometers (Exhibit 11).[17]

Exhibit 11

Spending on wafer fabrication equipment by semiconductor makers has increased since 2000, focusing on decreasing node size.

Distribution of spending on semiconductor wafer fabrication equipment, by node size, %

*Values for 130 nanometer node size include spending on equipment for all node sizes 130 nanometers and larger.
Source: Gartner (for full information, see endnote 17)

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Over the same time span, much of the industry adopted a "fabless" business model, with some companies handling the design and sale of semiconductors while outsourcing fabrication of the physical microchips to other companies called foundries. Some players, including Nvidia, Qualcomm, and Broadcom, specialized in designing microchips that served specific purposes.[18] Others, such as TSMC, specialized in manufacturing chips designed by fabless players, while ASML and others focused on the specialized equipment used to make chips (for instance, for lithography). As a result, the industry underwent a dramatic shift from vertically integrated business models to disaggregated specialization. However, some players, notably Intel, maintained a vertically integrated design and manufacture model for microchips, while sourcing the tools in their factories from specialized suppliers.

Escalation mechanism for investments

The second potion ingredient can be observed in the type of investments players have incentives to make, namely escalatory investments. Escalatory investments have two mutually compounding consequences.

First, the returns of these investments increase with scale. These outlays not only grow output but fundamentally change and improve a company's production function. In other words, they increase quality, not just quantity. As a result, these investments can boost margins and rapidly expand market share, because customers want the best product. By contrast, so-called ticket-to-play investments, such as simply opening new factories and branches that aren't fundamentally different from existing ones, do not influence market position as much.

Second, players begin an arms race in which they iteratively invest to scale and scale to invest. When one player improves quality and starts to gain more profits and market share, other companies respond and invest more to improve the quality of their product to compete. The more each player invests, the more competitive the race becomes, creating an escalatory cycle. We expand on this intense mode of competition in the next section.

Escalatory investments are features of specific types of spending, such as marketing, R&D, and certain capital expenditures. These are the kinds of investments that advance a company's capabilities and tend to improve long-term margins. For example, when e-commerce platforms invest in marketing to attract more customers and increase the platforms' value for merchants, the cost of mass marketing to customers shrinks relative to revenue potential, expanding per-customer margins. Biopharma companies often invest in novel R&D methodologies, such as AI-driven bioinformatics, to improve clinical success rates and return on investment (ROI). Once a drug is produced and marketed, the cost of R&D investment is spread across that drug's sales. Acquisitions can be a form of R&D investment when they provide access to the capabilities and proprietary assets of the acquired companies. In many instances, an underlying network effect makes investments attractive for arena companies (a process we discuss later in this chapter). Furthermore, these types of investments are not one-offs when they are escalatory—they are continual and increasing.[19]

Of course, not all investment-intensive industries exhibit this escalatory dynamic. In the steel industry, building a new plant might increase overall profits, but only by increasing capacity and sales within the same production function. However, e-commerce players like Amazon, as they optimize last-mile delivery to the home, fundamentally change not just their scale but their unique capabilities, too (see sidebar "Tech giants made massive escalatory investments").

Sidebar: Tech giants made massive escalatory investments

If we look at six of the biggest players in several arenas, the magnitude of escalatory investments is enormous. These companies—Alphabet, Amazon, Apple, Meta, Microsoft, and TSMC—collectively invested $13 billion in capital expenditures and R&D in 2005. By 2020, that number had increased 20-fold, reaching almost $250 billion, a 22 percent year-on-year growth rate. By comparison, US capital expenditures rose 3 percent and R&D spending increased 7 percent in the same period.[1] This pattern of investments has continued since 2020, with all six companies maintaining 15 to 23 percent CAGRs on their R&D expenses and capital expenditures from 2020 to 2023.

Beyond the total size of investments, the allocation between R&D and capital expenditures also showed how investment strategies evolved. For example, Microsoft's capital investments were only $1 billion in 2005, while the company reported spending $6 billion on R&D. By 2020, its capital expenditures had reached $15 billion, not far behind the $19 billion for R&D. Alphabet, on the other hand, went from reporting roughly equal amounts for R&D and capital expenditures in 2005 to reporting nearly 30 percent more on R&D than on capital expenditures by 2020, and nearly 40 percent more by 2023 (exhibit).

[1] US capital expenditures cover US nonfarm businesses; 2020 Annual Capital Expenditures Survey, US Census Bureau, December 2021.

Exhibit

Investments by big tech players escalated 20-fold from 2005 to 2020.

Select companies' spending on capital and R&D, $ billion

[1]Meta's multiple and CAGR numbers are indexed to 2010 instead of 2005 due to data availability.
[2]Amazon's R&D expenditure uses the company's "technology and infrastructure" expense, reported under the GAAP requirement ASC 730 for research and development expenses.
Source: McKinsey Value Intelligence; McKinsey Global Institute analysis

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To illustrate this dynamic within an arena, we looked at four of the largest players in our sample of cloud-services companies from 2015 to 2020 to determine whether escalating investments—as indicated by the level of capital expenditures—correlated with outsize revenue market share (Exhibit 12). In 2015, AWS was the market leader with 23 percent of revenue market share, followed by Microsoft at 16 percent. In 2020, AWS still led in revenues with 37 percent market share, and Microsoft followed with 21 percent. The continual escalation of these investments is clear: AWS and Microsoft pulled further and further ahead to first gain and then at least maintain their market share.

Exhibit 12

In the cloud services arena, capital expenditures continued to escalate amid intensifying competition.

4 companies' cloud services revenue and capital expenditures, 2015–20

[1]Revenue is proportionally adjusted to relevant business units (eg, AWS for Amazon).
[2]Capital expenditures are estimated by applying the revenue split of each company into business units to each company's reported capital expenditures, cumulative starting 2015, 5-year straight-line depreciation applied.
Source: McKinsey Value Intelligence; McKinsey Global Institute analysis incorporating data from IDC

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Large or growing addressable market

Technological and business model step changes open demand pools that are conducive to escalatory investments. As a result, these changes unlock large and often rapidly growing addressable markets—our third potion ingredient. Generally speaking, there are two ways for companies to reach large or fast-growing markets: either they play in already sizable markets where demand growth continues to outstrip the rest of the economy or they displace share of an existing large market with a superior product or service.

Companies in the first category took advantage of technology and business model step changes to accelerate value creation in fast-growing, established industries, which typically had revenue pools of more than $100 billion in 2005 but were subject to escalatory investments that improved efficiencies or broadened capabilities. These arenas included biopharmaceuticals, industrial electronics, information-enabled business services, mobile and consumer electronics, payments, semiconductors, software, and video and audio entertainment. Together, they recorded 5 to 13 percent revenue CAGRs from 2005 to 2020. By comparison, the global economy expanded about 3 percent a year during the same period.[20] For these arenas, the growth driver of the market was often an expansion of existing demand brought about by digitization and associated globalization. In 2020, 60 percent of revenues earned by the companies in these arenas came from outside their home countries.

Companies in the second category achieved rapid growth by launching novel categories of products or services, taking shares from existing markets.[21] While companies in the first category used technology and business model step changes to accelerate growth in existing industries, those in the second category created new industries, which captured growth by eating into the demand from existing markets. These arenas include cloud services, consumer internet, e-commerce, and EVs. Their revenue grew at a 13 to 33 percent CAGR from 2005 to 2020.

In this group, digitization often created a superior value proposition. The worldwide adoption of internet connectivity allowed e-commerce players to more seamlessly connect buyers and sellers across the globe, providing the opportunity for customers to purchase goods anytime, anywhere with their electronic devices, rather than through traditional physical retail channels. Digitization also transformed video and audio entertainment, and streaming in particular, by shifting media consumption from movie theaters and physical CDs to homes and mobile devices. Players were able to offer the added flexibility of content options and scheduling to consumers. We further discuss the importance of digitization later in this chapter.

We have discussed the three elements of the arena-creation potion: a technological or business model step change, escalatory investments, and a large or growing addressable market. We observed that the combination of these three ingredients, over time, leads to the formation of arenas. Next, we expand on the new competitive game unique to arenas when these three ingredients coalesce, which we call an escalatory mode of competition.

The three ingredients result in an escalatory mode of competition

Arenas produce a unique competitive tussle—an escalatory mode of competition—which results in high growth and high dynamism.

Escalatory competition is the industry-level consequence that occurs when the three potion elements come together, resulting in individual companies facing escalatory investment incentives. As alluded to above, it is characterized by arms-race-style contests in which players continually invest in their products, advertising, and operations because a technological or business model step change has disrupted the industry and unleashed latent demand.

To compete for or even maintain market share, companies need to continually increase investments and improve their capabilities.

As arena companies invest more in capabilities and the quality of their products improves, their profit eventually rises. They achieve this by increasing customers' willingness to pay (with product improvements or advertising, for example), by reducing costs (by making step-change improvements in customer acquisition costs, for instance), or by growing volumes (for example, by leveraging network effects). Further, advancing capabilities tends to allow companies to expand their economic catchment zones: they can now sell products and services beyond old boundaries of geographies or categories.

The competitive landscape changes as an arena moves up the S-curve of technical capability and adoption. Initially, the possibility of translating innovation to better capabilities and rapid market share can pull in new entrants at the beginning of the S-curve. Escalatory competition then tends to occur during the phase of rapid growth. This movement of an industry along the S-curve marks high levels of growth and competitive dynamism with major market share shifts, both of which are hallmarks of an arena. Eventually the escalatory investment dynamic can put leaders out of reach in the plateauing phase of the S-curve as new market players may find it increasingly challenging to compete with the capabilities that incumbents have developed, limiting the number of players, although they could continue to compete vigorously with one another.

There are two other general modes of competition. Simple competition features low barriers to entry and minor competitive advantages. Mature markets competition occurs when a few large players capture a significant portion of market share. What distinguishes escalatory competition from the other modes is that players are required to keep improving product quality, enabled by new technologies and rewarded by large addressable markets, intensifying the battle for market share. To compete for or even maintain market share, investments and capability-building must be continual; players that do not match the velocity of investments would eventually be unable to compete. Other modes of competition do not result in this kind of escalatory dynamic (see sidebar "The differences between the general modes of competition").

Sidebar: The differences between the general modes of competition

Three general modes of competition demonstrate why escalatory competition is different and is characteristic of arenas.

In the first mode, simple competition, barriers to entry are low and individual players cannot unilaterally move prices. This is the case with a neighborhood laundromat or locksmith: a minimal investment is required to enter, the technology is well understood, there are many small players, competition is high, and the competitive advantages, if they exist, are minor.

The second mode, mature markets competition, is a model in which a few large companies have captured a significant portion of the market share. This often occurs at the plateauing end of the S-curve, where technological performance or adoption reaches maturity. New rivals are limited by high barriers to entry like a minimum efficient scale or high capital investment. In this mode, the parameters of the competitive game seem settled for some time, with established business models as well as physical or intangible assets and capabilities. A prominent example is the long-haul commercial airline industry, where high levels of up-front investment in aircraft are necessary to operate at scale, while regulatory requirements and limited landing slots constrain the entry of new players. As a result, competition tends to revolve around pricing shifts. Under mature markets competition, the market tends toward equilibrium, although competitive escalations, technological or business model step changes, or both can disturb that equilibrium.

The third mode, escalatory competition, is characterized by an arms-race dynamic in which players continually invest to advance their capabilities. In his 1991 book *Sunk Costs and Market Structure*, the economist John Sutton presented a theory that helps explain the difference between mature markets competition and escalatory competition. He asserts that company investments can be described as either exogenous sunk costs or endogenous sunk costs. Exogenous sunk-cost investments are those that any player needs to make to enter the market. Examples include the cost of building a factory or of setting up a logistics and distribution network, or the heavy capital investments required in the commercial airline industry. Endogenous sunk costs are fixed investments that improve long-term profit by reducing cost or increasing customers' willingness to pay. These investments are classified as endogenous as they tend to depend or build upon investments already made. Think of product improvements or marketing campaigns that allow companies like Apple or Samsung to maintain the price of their products, or a process innovation that optimizes production performance (for example, investments by Intel, TSMC, or Nvidia that permit the company to efficiently produce at smaller nodes). The cost savings that companies derive from economies of scale are typically the returns from endogenous sunk-cost investments.

Escalatory competition occurs when markets are suited to endogenous sunk-cost investments. In such cases, incumbent companies will keep investing in R&D, marketing, or capital expenditures. As a result, current players advance their capabilities and can even expand to other markets. The most dynamic competitively escalatory industries—and hence arenas—are often found at the beginning of the S-curve, when technological or business model step changes occur, or in the succeeding, middle phase of rapid growth in the S-curve.

For example, we observed competitive escalatory dynamics in the consumer internet arena, especially in the early years of Meta as the company continued to invest in capabilities and expanded demand from 2005 to 2020. Acquisitions made by large players are sometimes signs of mature markets competition, so Meta's acquisitions of WhatsApp and Instagram might have suggested that the consumer internet arena was reaching an S-curve plateau. But we also see innovations that create new dynamism: TikTok, for example, started to meaningfully compete in the consumer internet arena after it launched in China in 2016 and expanded internationally in 2017. By 2020, TikTok had more than 1 billion users, while Facebook had almost 2 billion. New business models and redefined industry lines may produce the arenas of tomorrow. We discuss this further in chapter 3 and in the compendium that follows it.

Other industries, including long-haul commercial air travel, also underwent shifts in competitive modes before our 2005–20 focus period. This market featured rapid innovation, high investment, and substantial market share reshuffling before a series of mergers and acquisitions led to the current stage of quality, especially for the largest players.

Observing the potion in the arenas of today

In this chapter, we've described the three ingredients of the arena-creation potion and explained why they result in high growth and high dynamism. In this section, we explore the importance of digitization in enabling the rise of the three potion ingredients and how these ingredients coalesced to create exceptional growth and dynamism in each of our arenas of today. We also explore metrics that could have signaled the emergence of these arenas (see sidebar "Early markers of arenas").

Digitization has been a primary force in expanding the number of industries where an escalatory competitive dynamic could develop.

Sidebar: Early markers of arenas

Beyond the arena-creation potion, we also explored metrics, such as capital flows, valuations, and revenue growth, that could signal the presence of arenas in their early stages. We discovered that these early markers varied in reliability but were nevertheless helpful in pointing to potential areas where arenas could emerge when they supplemented the three potion ingredients. What would these metrics have told us in 2005 about arenas in their infancy? We examined the following (Exhibit):

- *Venture capital.* A majority of VC flows—60 to 70 percent—went to arena-linked companies, but just four arenas drove this large share: biopharmaceuticals, consumer internet, semiconductors, and software. Most arenas received less than 3 percent of the total flows of venture capital in any given year from 2003 to 2007.
- *Heightened value expectations.* We might expect valuations (measured here as the ratio of enterprise value to net operating profit less adjusted taxes, or NOPLAT) to predict arena emergence. We did find evidence that in any given year from 2003 to 2007, the majority of arenas were in the upper half of the distribution of industries for valuation multiples. Only biopharmaceuticals had multiples that were consistently lower than industry medians. We also looked at the overall EV/NOPLAT multiples of arenas, which were generally higher than those of other industries in this period.
- *Revenue growth.* By definition, arenas had higher revenue growth than the economy over the 2005–20 period. We also examined year-on-year revenue growth for each arena in the years around the beginning of our period of analysis, from 2003 to 2008. As expected, we found that a majority of them grew faster than our overall sample.

These investment markers were telling indicators for several candidate arenas and helped guide us in estimating the arenas that might eventually emerge. However, like all predictive markers, they had limitations.

Sidebar: Early markers of arenas (continued)

Exhibit

Markers may point to a high likelihood of arenas forming.

Investment and revenue metrics during years when 12 industries emerged as arenas

■ Greater than or equal to benchmark □ Less than benchmark

	Venture capital investment,[1] $ billion					Valuation,[2] multiple					Revenue growth through following year, %				
	2003		2005		2007	2003		2005		2007	2003		2005		2007
Benchmarks[3] →	*1.1*	*1.3*	*1.8*	*2.0*	*2.5*	*21.3*	*19.8*	*20.7*	*20.9*	*19.8*	*14*	*6*	*14*	*17*	*1*
Biopharma	4.5	6.3	5.6	7.2	9.8	19.5	17.9	16.4	16.7	15.1	23	9	23	25	6
Cloud services	0.8	1.1	1.1	1.1	1.0	26.8	31.1	23.2	24.3	27.4	16	3	28	24	14
Consumer electronics	3.0	3.6	4.4	5.1	5.5	20.3	24.2	20.9	20.2	22.1	12	5	14	21	–5
Consumer internet	2.9	4.2	11.4	7.4	7.0	25.6	36.2	30.1	27.7	31.3	26	19	29	26	2
E-commerce	0.2	0.4	1.9	1.4	1.0	22.9	21.6	20.0	19.5	19.7	39	34	112	69	36
Electric vehicles	0.1	0.2	0.2	1.0	0.8	n/a					n/a			204	74
Industrial electronics	0.8	1.3	1.2	1.6	2.0	25.3	21.6	22.7	20.9	17.8	21	6	16	22	–1
Information-enabled business services	0.8	0.9	1.5	1.5	2.1	19.7	19.6	25.4	24.4	18.7	11	–14	8	20	1
Payments	0.9	0.7	1.6	1.5	2.8	56.3	48.6	48.8	24.4	28.2	16	–5	15	11	11
Semiconductors	3.0	3.1	2.8	3.0	3.2	41.8	20.0	20.0	18.4	18.7	35	3	12	10	–10
Software	11.7	13.7	18.9	20.0	26.5	25.4	27.4	21.5	23.1	24.3	15	9	20	24	16
Video and audio entertainment	0.5	1.0	1.2	3.6	3.4	24.6	23.7	23.2	23.7	19.8	2	–9	10	12	7

[1]Double counting of flows occurs in several instances where multiple arenas apply to one deal (eg, a payment start-up for e-commerce platforms would be counted in both payments and e-commerce).
[2]Defined as ratio of enterprise value to net operating profit less adjusted taxes (EV/NOPLAT).
[3]Benchmark for venture capital is at least 3% of total flows; for valuation, the EV/NOPLAT multiple for 57 industries; for revenue growth, the average of the total sample rate for that year.
Source: PitchBook; McKinsey Value Intelligence; McKinsey Global Institute analysis

Digitization enables network effects and globalization

Digitization has been a primary force in the simultaneous rise of the three potion ingredients by expanding the number of industries where an escalatory competitive dynamic could develop. For example, brick-and-mortar retailers face high hurdles to reducing unit costs through investments. A traditional retailer's marketing spend is only effective in the physical catchment of the stores, but an e-commerce retailer can spend into a much less constrained addressable market

Network effects, which increase the value of a product or service as more people use it, were accelerated by digitization in many arenas, including consumer internet, e-commerce, consumer electronics, and software.

For example, social media companies' networks become more valuable to users as they add more contacts on the platform. Search engines become more accurate and more valuable as more users engage with them and generate data that can be used to improve search results. E-commerce marketplace platforms have a two-way network-effect dynamic as more merchants increase the platform's value for customers and vice versa. For consumer electronics and the underlying software that runs them (such as iOS and Android), a mutually reinforcing network effect connects developers and users: more users entice developers to produce more applications, which in turn attracts more users.

Globalization of some industries was also a consequence of digitization. Products and services that would traditionally have local or regional reach are now accessible anywhere. This is particularly obvious for internet-dependent arenas, such as cloud services, consumer internet, e-commerce, and software. In the video and audio entertainment arena, even before streaming became commonplace, globalization had already expanded consumers' ability to access media, as seen with K-pop's rise to international prominence. Globalization also uniquely influenced the information-enabled business services arena by sparking accelerated growth in the knowledge economy, which prompted companies in this area to boost their investments in capabilities to address a newly global addressable market.

The three potion ingredients in the arenas of today

Here we examine how the three potion ingredients have contributed to creating today's arenas, discussed in descending order of 2020 revenues.

Industrial electronics. This arena consists of two groups of companies: contract manufacturers, such as Foxconn, Jabil, and Flex, and OEMs, such as Panasonic and Schneider Electric.

For contract manufacturers, the large-scale outsourcing of manufacturing was the significant business model step change that made this industry an arena. High-revenue players, such as Foxconn, benefited from the manufacturing outsourcing of big brands, such as Apple and Sony. As a result, contract manufacturers often escalate investments in capital expenditures in line with growing manufacturing capacity and in R&D to build capabilities as they meet demand.

We can see the escalatory nature of the capital investments by the largest contract manufacturers (Exhibit 13). From 2005 to 2020, Foxconn's outlays were associated with higher revenue growth than was the case for its two closest competitors. In 2005, Foxconn had more revenues than Jabil and Flex, and it devoted a high share of revenues, 5 percent, to capital expenditures. Jabil and Flex spent 3 and 2 percent, respectively. Foxconn's continued customer commitments allowed it to continue this high allocation of capital expenditures as its competitors trailed behind: Jabil's capital expenditure allocation reached 5 percent of revenues only in 2015. Foxconn's revenues continued to outpace those of competitors, and by 2020, the company spent only 1.2 percent of revenues on capital expenditures (capital expenditures still grew, but not as fast as revenues), while Jabil spent 3.6 percent of revenues.

Exhibit 13

Foxconn's capital investments have been accompanied by rising revenues.

3 contract manufacturers' revenue and capital expenditures, 2005–20

[1]Capital expenditures cumulative starting 2005, 10-year straight-line depreciation applied.
Source: IDC; McKinsey Value Intelligence; McKinsey Global Institute analysis

McKinsey & Company

To some extent, the capital expenditure investments by the contract manufacturers were as much about boosting quantity as quality, and less escalatory in that sense.[22] For OEMs, the increasing digitization of physical devices and equipment was a technological step change that spurred growth. In this case, OEM players escalated both capital investment and R&D to develop novel manufacturing processes and the software embedded in these digitally enabled products. For example, Panasonic announced in 2006 that it would stop manufacturing analog televisions and concentrate on digital televisions. Siemens invested about $10 billion throughout the 2010s to strengthen capabilities in its Digital Factory.[23] Increasing demand for downstream products raised revenues for these OEMs as well as the revenues for upstream electronic components produced by contract manufacturers. The industrialization of developing economies accounted for a large part of the demand growth in this arena. In our sample, this arena was the largest by revenues in both 2005 ($389 billion) and 2020 ($987 billion).

E-commerce. A business model step change enabled the e-commerce arena as retail sales increasingly took place online instead of in physical stores. This was made possible by the growing penetration of personal computers, mobile devices, and internet connectivity. E-commerce players escalated investments in physical distribution networks to improve delivery cost margins and delivery times, increasing customer satisfaction and their value.

Players also escalated investments in marketing to acquire more customers, as scale gives companies more purchasing power to negotiate favorable terms with suppliers. Marketplace and platform players further escalated these marketing investments to acquire both customers and merchants, which enables a mutually reinforcing network effect: customers find more value in a platform with many merchants and vice versa. This network effect is an important part of Amazon's "flywheel effect," which incorporates escalatory investments in pricing and customer experience.[24]

In market size and growth, the e-commerce market disrupted the already large traditional retail market, whose revenues grew from $1.2 trillion in 2005 to $2.5 trillion in 2020, a growth rate of 5 percent. Meanwhile, e-commerce's revenues grew from $15 billion in 2005 to $874 billion in 2020, a 31 percent growth rate. E-commerce's share of total retail sales in the United States was 2.5 percent in 2005. By 2020, it was 15 percent.

Consumer electronics. The evolution of mobile phones into smartphones was a technology step change in this arena that resulted from escalatory investments in R&D aimed at integrating multiple new technologies—including semiconductors, digital displays, cameras, batteries, and software operating systems—into one compelling solution.

The shift to smartphones also expanded mobile phones' value beyond simple communication tools to multipurpose devices, creating software ecosystems. The emergence of these software platforms created a business model step change: the arrival of application stores and application revenues. Apple launched its application store in 2008, and Google introduced its own in 2012. To acquire customers for their platforms and build brand loyalty, players escalated investments in marketing (for example, Samsung spent $3 billion, or 3.8 percent of total revenues, on marketing in 2005, and $9.7 billion, or 4.8 percent of revenues, in 2020).

Players also escalated R&D investments intended to constantly integrate software and hardware innovations. Investments in underlying operating systems (iOS and Android, Mac OS and Windows) also escalated as players sought to accelerate network-effect dynamics for developers and users: mobile operating systems capabilities attract more developers to develop applications, and more applications attract more users. This creates an incentive for developers to produce apps for operating systems with more users. This arena accessed the large and growing demand for mobile devices. In 2005, only 34 percent of the global population had any kind of mobile phone; by 2020, 67 percent of the global population had a smartphone. In addition, the global population grew 20 percent over this period.

Semiconductors. As discussed above, this industry experienced constant step changes of technology S-curves in the form of node resets. For semiconductor manufacturers, including foundries and integrated design and manufacturing players, investments escalated to stay on the cutting edge of each successive node. Tool suppliers also escalated R&D to create tools to manufacture smaller and smaller features; for example, extreme ultraviolet lithography required billions of dollars over decades. Fabless players that designed semiconductor products escalated R&D investments in the same ways as software companies: constant innovation was required to create new products and enhance existing ones to remain competitive. Semiconductors' revenues in our sample nearly tripled from $194 billion in 2005 to $574 billion in 2020, driven by rising demand for computing systems (PCs and servers) and mobile devices.

Video and audio entertainment. This arena's business model step change was the development of on-demand streaming of video and audio, which offered increased accessibility of content unbounded by time or physical constraints, disrupting the way traditional media was consumed. To attract more customers, players escalated investments in content development, such as licensing material and in-house production. With scale, players also had more purchasing power to negotiate terms with content creation ecosystems, whether licensing content or producing it in-house. Further, R&D investments escalated to improve the customer experience, for instance by leveraging customer data—using recommendation algorithms, for example—to drive customer satisfaction and retention. Global consumption of media grew over this period, with digital entertainment as a driving force. This arena's revenues more than tripled, from $149 billion in 2005 to $424 billion by 2020.

Consumer internet. The global rise of the internet and broader digitization created the opportunity to serve consumer needs through services like social media and web search. Though membership-based internet access providers such as AOL were still common in 2005, consumer internet players began to implement a step change in their business model. This change enabled these services to rapidly acquire large user bases that were monetized through advertising and sold through online auctions. Consumer internet players were also able to offer marketers a new business model of ads that link fees to clicks rather than impressions. Another business model innovation was the new ability to hyper-target customer segments that traditional platforms like print publications, cable TV, and billboards could not achieve. In terms of investments, players escalated marketing spending to accelerate user acquisition and enable network effects. More users and more collected data increased the value of platforms by helping search engines refine results. For social media players, each additional user increased the value of the network for other users. For search engines and social media platforms, network effects amplified this virtuous cycle of consumers using players' platforms.

Biopharma. The introduction of drug discovery and production advancements, such as recombinant DNA technology, genome sequencing, and other platform technologies, presented new developmental paths for drugs that provide more targeted and effective therapies for patients. The escalation of investments in R&D was driven to a large extent by a need to discover and develop drugs that either were more effective than existing therapies or treated additional indications. For example, therapeutic-area-focused biotech companies continually invested to take advantage of technological curves, including AI-driven bioinformatics. Many of these companies had higher ROI and clinical success rates than traditional pharmaceutical businesses' R&D and in-house discovery engines. Due to the long runway of R&D-to-market cycles in pharmaceuticals, one could argue that this competitive dynamic may have begun as early as the 1990s, with revenue growth from biopharmaceuticals becoming materially observable from 2005 to 2020.

Global pharmaceuticals revenues were $601 billion in 2005. That figure more than doubled to reach $1.3 trillion by 2020, with biopharmaceutical businesses' share of the pool growing from an estimated 20 percent in 2005 to 50 percent by 2020, indicating that the lines have already blurred between biopharmaceuticals and pharmaceuticals. Biopharma revenues grew 13 percent year-on-year from 2005 to 2020.

Software. The emergence of software as a service (SaaS) caused step changes in business models in this arena. For example, in 2013, Microsoft launched Office 365 (after a beta that started in 2010), and Adobe transitioned its Creative Suite into the Creative Cloud. Players escalated investments in R&D (for example, collecting usability data or enhancing features) to retain customers and launch new products or features to drive lifetime customer value. This trajectory was followed by both customer relationship management software players, such as Salesforce, and enterprise resource planning software players, such as Oracle and SAP. Salesforce spent $9.8 million on R&D in its 2005 fiscal year. By 2020, that had grown to $2.8 billion. Oracle invested $1.5 billion in R&D in 2005

and $6.1 billion in 2020. SAP invested €1.1 billion in R&D in 2005, which increased to €4.5 billion by 2020. As with other arenas, the digitization wave spurred growth: the number of software use cases increased, computing power available in the cloud multiplied, and higher-performance internet connectivity made SaaS feasible for more customers. Software revenues grew 11 percent year-on-year, from $70 billion in 2005 to $349 billion in 2020.

Information-enabled business services. The emergence of outsourcing and offshoring services, including business process outsourcing and outsourcing IT and knowledge services, was a major business model step change in this arena. In addition, the increasing sophistication of data analytics capabilities, enhanced computing power, improved communications and networking technology, and digitization encouraged players to pivot to IT asset-based service delivery to supplement talent. Investments through acquisitions, primarily for the addition of new capabilities, talent, and data, escalated in this arena. For example, ADP completed 28 acquisitions from 2005 to 2020, and the credit-scoring agencies Equifax, Experian, and Transunion collectively acquired about 150 companies in that time.[25] The expansion of this arena was driven by the proliferation of the knowledge economy that followed in the wake of globalization and by the growing need to integrate technology into global businesses. Our sample shows that revenues in this arena almost tripled, from $68 billion in 2005 to $150 billion by 2020 at a 5 percent year-on-year growth rate.

Payments. Digitization caused a step change in payment systems by enabling them to be faster, more convenient, and often cheaper than offline payment solutions. As with e-commerce, players escalated investments in marketing to acquire merchants and customers, which created mutually reinforcing network effects. There was also escalation in R&D to enhance product features such as better security, fraud detection, and customer experience that enhanced the value proposition for merchants and customers. The payments industry was already large and growing, with global revenues that rose from $34 billion in 2005 to $146 billion in 2020, representing growth of 10 percent year-on-year. The majority of the growth was from emerging markets, such as China. In 2020, more than half of global payments revenues were from the Asia–Pacific region.

Cloud services. Cloud services exemplify a business model step change, because the companies offered computing and storage as operating expenses, freeing customers from rigid capital expenditures based on purchasing hardware. This business model provided flexible IT infrastructure solutions on a pay-for-what-you-use basis. The widespread deployment and penetration of the internet helped hasten the adoption of cloud services. Cloud-services players escalated investments in capital spending to build more data centers. They also improved economics of scale and price competitiveness and offered efficiencies, such as proximity and energy efficiency, to their customers. There was some R&D investment escalation as these players offered more value-added services, including advanced security options and analytics, as well as APIs for developers to ease integration with customers' systems. This arena disrupted the pool of corporate spending in physical IT infrastructure: global IT spending mostly came from traditional on-premises solutions in 2005, but by 2020, cloud-services spending accounted for $370 billion, or more than a third of the $1.1 trillion in global outlays.[26]

EVs. Rapidly improving battery and electric power train technology, as well as the ability to integrate these new technologies into one product, provided the technology step changes that led to an increasingly competitive market for EVs. The R&D investments for batteries, power train technology, and other production processes escalated to lower costs and increase performance. R&D investments also went toward improving other automotive technologies, including the ability to download software to vehicles, similar to the way application stores operate for mobile phones. Escalating outlays for marketing to convey competitive value to customers supplemented these investments.

The EV arena cut into the revenue pool of traditional ICE vehicles. That industry had $1.7 trillion in revenues in 2005, which grew to $2.4 trillion by 2020. By then, EVs had become a $100 billion revenue arena, equivalent to almost 5 percent of the established traditional automotive industry.

While other important industries stood out from 2005 to 2020, they did not show the outsize growth and dynamism that would qualify them as arenas. Our potion can help us understand why.

The apparel and luxury industry showed a relatively high industry share growth rate during this period—comparable to the biopharma and payments arenas—but displayed limited dynamism among the largest companies. This industry lacked a technology or business model step change of the same degree as the 12 arenas of today, one of the key ingredients of the potion. This meant that the same small group of players could vie for the growing demand pool in mature markets competition.

Conversely, oil and gas showed high dynamism with large share shifts among players while the industry share growth rate in this sector was far lower than the average in our overall sample: the market caps of oil and gas players grew at a 4 percent CAGR from 2005 to 2020, compared with average growth of 16 percent in our arenas. The industry experienced observable technology step changes, such as the advent of horizontal drilling and hydraulic fracturing in shale and other geological formations. However, oil and gas did not display an escalation mechanism for investments, another key potion element, and the huge capital outlays in the sector mostly go toward exogenous sunk costs, such as exploration and drilling of wells. This meant that growth was more linked to price changes from global events affecting supply and demand—such as the 2007–08 financial crisis, the COVID-19 pandemic, and the rapid proliferation of North American shale—as well as non-economic factors, than to an escalation of investments made by players.

▪ ▪ ▪

Arenas do not start from scratch. While early signals may appear noisy, they can still be helpful in helping us identify the primordial ooze from which arenas emerge. The arena-creation potion described in this chapter and evident in the arenas of today can provide an initial guide for identifying potential arenas of tomorrow. We can begin by looking for early signs of S-curve step changes, the starting gun of a new escalatory competitive race. For this race to eventually lead to the creation of an arena, the three ingredients usually must be in place.

In chapter 3, we look at the potential arenas of tomorrow and how they might evolve. Given the dynamic nature of arena competition, our ability to speak with certainty about which arenas will emerge is limited. But using our potion and the theoretical framework we set out in this chapter, we can identify certain aspects of arenas and present potential scenarios for their size and competitive dynamics in the coming years.

CHAPTER THREE

The arenas of tomorrow

The arenas of today have brought sweeping change to our lives over the past two decades. The arenas of tomorrow are likely to bring even greater change in the years ahead.

In chapters 1 and 2, we looked at the past and explored how the arenas of today grew and evolved, propelled especially by digital technologies. In this chapter, we look toward the future to identify 18 potential arenas of tomorrow that could exhibit high growth and high dynamism (see sidebar "How we defined the arenas of the future"). These arenas have the potential to transform our world in a number of areas, including transportation, healthcare, digital connectivity, energy, and entertainment.

In 2022, the industries we identified as the potential arenas of tomorrow took in $7.2 trillion in combined annual revenues. In our modeled scenarios, their revenues could grow to between $29 trillion and $48 trillion by 2040, at a CAGR of 8 to 11 percent from 2022 to 2040. For reference, the revenues of our arenas of today listed in chapter 1 climbed at a CAGR of 10 percent from 2005 to 2020, while revenue in other industries increased at a 4 percent CAGR. When we apply the typical after-tax profit margins observed in these arenas, our estimates show that potential future arenas could generate $1.9 trillion to $6.1 trillion in profits by 2040 (Exhibit 14).[27]

The revenue of arenas could represent a growing share of global GDP: from 4 percent in 2022 to 10 to 16 percent by 2040.

Exhibit 14

The 18 potential arenas of tomorrow could generate $29 trillion to $48 trillion in revenues and $2 trillion to $6 trillion in profits.

18 potential arenas of tomorrow, by 2040 revenue estimate, $ billion	Revenue, 2022	2040 estimate (CAGR, 2022–40, %)	Profit, 2040 estimate,[1] $ billion (profit margin, %)
E-commerce	4,000	14,000–20,000 (7–9)	280–1,000 (2–5)
AI software and services	85	1,500–4,600 (17–25)	230–920 (15–20)
Cloud services	220	1,600–3,400 (12–17)	160–510 (10–15)
Electric vehicles	450	2,500–3,200 (10–12)	100–320 (4–10)
Digital advertisements	520	2,100–2,900 (8–10)	320–580 (15–20)
Semiconductors	630	1,700–2,400 (6–8)	340–600 (20–25)
Shared autonomous vehicles	n/a	610–2,300	20–460 (4–20)
Space	300	960–1,600 (7–10)	50–160 (5–10)
Cybersecurity	160	590–1,200 (8–12)	90–240 (15–20)
Batteries	98	810–1,100 (12–14)	40–110 (5–10)
Modular construction	180	540–1,100 (6–10)	20–220 (4–20)
Streaming video	160	510–1,000 (6–11)	50–150 (10–15)
Video games	230	550–910 (5–8)	80–180 (15–20)
Robotics	21	190–910 (13–23)	20–180 (10–20)
Industrial and consumer biotech	140	340–900 (5–11)	10–270 (4–30)
Future air mobility	n/a	75–340	10–70 (10–20)
Drugs for obesity and related conditions	24	120–280 (9–15)	30–100 (25–35)
Nuclear fission power plants	18	65–150 (7–13)	5–50 (5–30)
Total	**7,250**	**29,000–48,000 (8–11)**	**1,900–6,100**

[1]Defined as net operating profit less adjusted taxes (NOPLAT). NOPLAT share based on most closely mappable industries from our database of 3,000 companies analyzed in chapters 1 and 2.
Source: Company annual reports; McKinsey Value Intelligence; McKinsey Global Institute analysis

McKinsey & Company

While the revenue and after-tax profit margin estimates broadly followed the same ranking as shown in Exhibit 14, the orders do deviate slightly due to business model differences. For example, if current profit margins persist, the semiconductor arena would generate profit margins of 20 to 25 percent, making it the third-largest arena by potential 2040 profit (when ranked by the higher range of estimates) though it is only the sixth-largest arena by 2040 revenue. By contrast, the EV arena, which ranks fourth by 2040 revenue (also ranked by the higher range of estimates), would rank seventh by potential 2040 profit if the industry's profit margins continue at 4 to 10 percent.

We also estimate that the revenue of arenas, converted into GDP terms, could represent a growing share of global GDP: from 4 percent in 2022 to 10 to 16 percent by 2040.[28] This translates to a 18 to 34 percent share of total GDP growth (Exhibit 15). This shift in GDP share and value creation is a hallmark of arenas. If we perform a similar analysis on our arenas of today, the revenues of our sample companies also increased their corresponding share of GDP, from 3 percent in 2005 to 9 percent in 2020.[29] Capital flows also indicate the appeal of the arenas of tomorrow for investors. By our estimates, about a third of venture capital flows from 2020 to 2023 went to industries linked to our potential future arenas.[30]

With an internet penetration rate of just 35 percent, developing economies have large untapped potential for digital products and services.

Exhibit 15

The 18 potential arenas of tomorrow could contribute a third of global GDP growth.

Global GDP, $ trillion

Note: Figures may not sum to 100%, because of rounding.
Source: OECD; Bureau of Economic Analysis; McKinsey Value Intelligence; McKinsey Global Institute analysis

McKinsey & Company

In chapters 1 and 2, we showed how digitization was the main underlying force in the formation of the arena-creation potion for most of today's 12 arenas. For our list of 18 potential future arenas, we identified four thematic "mega-forces" that will likely drive their future growth and dynamism: continued digitization, innovations in the physical world, the global energy transition, and a growing, more prosperous world.

First, the continually improving capabilities of digital technology could accelerate growth when the product is information or a digital interface, driven by companies' continuing efforts to move workloads to the cloud, the growing complexity of cybersecurity needs, and the rapidly expanding capabilities of AI. The continued expansion of the internet in developing economies may also drive growth for arenas like e-commerce and digital advertising. For instance, internet penetration is estimated at 35 percent in developing economies today, compared with 80 percent in developed economies—a disparity that illustrates the large untapped potential for digital products and services in developing economies.[31] Second, innovations are bringing new technologies to the physical world

with advancements such as robotics and shared autonomous vehicles. Third, the global energy transition and the underlying momentum to decarbonize are likely to boost demand for cleaner energy and products, including EVs, batteries, and nuclear fission power plants. Fourth, as the global population grows and becomes more prosperous, demand will grow for industries that address quality-of-life needs in areas ranging from healthcare to homes.

We have identified three groups of arenas, differentiated by the way they become potential arenas of tomorrow (Exhibit 16). The first group, continuing arenas, is made up of four of the 12 arenas of today that we have identified as potential future arenas because they will likely continue to exhibit high growth and high dynamism. The second group, spin-off arenas, consists of specific portions of current arenas that are likely to have their own trajectories of high growth and high dynamism. The third group, emergent arenas, is made up of new industries that have high potential for growth and dynamism and have exhibited early signs that the arena-creation potion elements are coalescing. Together, these three groups of arenas make up our 18 potential future arenas. Other industries were also considered, such as those we designated as “ceasing” arenas and a set of industries that almost qualified as emergent arenas. We chose not to analyze these potential arenas in depth because of uncertainties about size and dynamism, the likelihood of the scenario, and the time frame for scaling.

Exhibit 16

The 18 potential arenas of tomorrow include arenas of today, spin-off arenas, and emergent arenas.

How certain industries might emerge as arenas of tomorrow

Why other industries considered might not emerge as arenas of tomorrow

5 arenas of today *could lack the growth and dynamism through 2040 to continue as arenas of tomorrow.*

- Biopharma
- Consumer electronics
- Industrial electronics
- Information-enabled business services
- Payments

8 almost-emergent arenas *might show high growth and dynamism through 2040 but were not analyzed because of uncertainties about the likelihood of the scenario and the time frame for scaling.*

- Clean hydrogen
- Lower-carbon materials
- Nuclear fusion
- Products and services for older adults
- Renewable energy generation equipment
- Sustainable fuels
- Virtual reality and augmented reality
- Web3, including decentralized finance

Source: McKinsey Global Institute analysis

McKinsey & Company

The following consists of thumbnail sketches of the industries that could become the 18 arenas of tomorrow, along with our assessment of the factors influencing their growth and dynamism. We also outline swing factors, potential future developments that could greatly affect the growth or dynamism of the arena. The compendium that follows this chapter describes these aspects of the arenas in more depth.

The 18 potential arenas of tomorrow

Below and on the following pages are thumbnail sketches of 18 industries that could become the arenas of tomorrow, arranged in descending order of 2040 high-case revenue scenario. Each includes a very brief summary of the **growth factors** that could drive the expansion of each industry's revenues, the **dynamism factors** that could generate shifts in market shares between players within these industries, and the **swing factors** that could push an industry towards the higher or lower end of the range of scenarios.

E-commerce

Companies that sell goods through digital channels and fulfill them directly

Growth factors
New formats, such as social and quick commerce, expansion of categories in developed economies, and higher penetration in developing economies

Dynamism factors
Maintaining a few large players with some disruption from direct-to-consumer companies, growth in the grocery segment, and regional players

Swing factors
Social commerce, adoption of AI , innovation of physical retail, pick-and-deliver economics

$14 trillion–$20 trillion
Revenue in 2040

AI software and services

Companies that provide software and services incorporating AI, excluding hardware necessary to operate AI

Growth factors
Analytical AI and generative AI enabling enterprise use cases and boosting individual productivity

Dynamism factors
Massive investment and scale allowing a few large players to develop among frontier foundation models; fragmentation in the segment providing specialized software for targeted use cases

Swing factors
Semiconductor supply and computational power, market fragmentation due to geopolitical developments, evolution of value distribution among value chain, and impact of open-source models

$1.5 trillion–$4.6 trillion
Revenue in 2040

Cloud services

Companies that deliver on-demand cloud infrastructure and platforms as a service

Growth factors
Continued migration from on-premises computing and storage to the cloud, renewed demand from computational requirements of newer technologies like AI

Dynamism factors
Likely to continue to have a few large players, with possible shifts due to emerging regional competitors and a growing segment of cloud services for AI

Swing factors
Data sovereignty regulations, gen AI adoption, cloud migration costs, responses to a cybersecurity event

$1.6 trillion–$3.4 trillion
Revenue in 2040

Electric vehicles

Manufacturers of battery, plug-in hybrid, and fuel-cell electric vehicles

Growth factors
Improving range and value for money, consumer willingness to pay for sustainable products, and a sufficient supply and distribution of electricity to EV charging infrastructure

Dynamism factors
Existing large global OEMs with new EV offerings competing with new EV-focused entrants, as well as increasing competition from Chinese-based EV manufacturers

Swing factors
Ramp-up of sufficient charging infrastructure affecting consumer preference, regulatory support of EV adoption, raw material needs, sufficient generation of clean electricity

$2.5 trillion–$3.2 trillion
Revenue in 2040

Digital advertisements

Platforms that enable advertisers to reach consumers digitally

Growth factors
Growing middle class, more consumer time on digital media, new ad products and placements

Dynamism factors
Degree of globalization of walled gardens, new ad formats, convergence of commerce and advertising, regulatory and data privacy actions, shifting consumer eyeballs

Swing factors
Interoperability between platforms, impact of gen AI, competition in new media formats, price and margin impacts of new ad inventory

$2.1 trillion–$2.9 trillion
Revenue in 2040

Semiconductors

Designers and manufacturers of semiconductors, microchips, and integrated circuits, as well as providers of tools for semiconductor manufacturing

Growth factors
Rising demand for computing and data storage, wireless communication, and industrial electronics; increasing number of semiconductors used in automotive

Dynamism factors
Some share-shifting possible as players move from general-purpose to domain-specific chip manufacturing or as tech players vertically integrate into design or manufacturing

Swing factors
Geopolitical dynamics, competition in AI-specific chips, slowdown in investments, price erosion, slowdown in Moore's law

$1.7 trillion–$2.4 trillion
Revenue in 2040

Shared autonomous vehicles

Operators of shared autonomous vehicle services

Growth factors
Technological progress, financial feasibility, consumer acceptance

Dynamism factors
Nascent but likely to have a few large players given high R&D costs and barriers to entry

Swing factors
Regulatory framework for liability, consumer safety concerns, overcoming of technological hurdles, different business models

$610 billion–$2.3 trillion
Revenue in 2040

Space

Providers of outer-space-related infrastructure and services to the commercial and state-sponsored segments

Growth factors
Growing demand in commercial services and end-user equipment, lower cost of satellites, introduction of reusable heavy rocket launchers, increased government spending

Dynamism factors
Commercial infrastructure and state-sponsored defense and intelligence players see higher barriers to entry due to R&D requirements; higher potential for entrants in end-user equipment and services and state-sponsored civil segments

Swing factors
Evolving consumer demand in the commercial segment, geopolitics affecting global market structure, proliferation of space use cases

$960 billion–$1.6 trillion
Revenue in 2040

Cybersecurity

Companies that provide protection of computer systems from unintended and unauthorized access, modification, or destruction

Growth factors
Improving capabilities of attackers, growing data sets, new business models vulnerable to attacks, cybersecurity regulatory requirements

Dynamism factors
High fragmentation due to multiple segments and local regulations, but could have fewer players if platforms emerge

Swing factors
Emergence of new cybersecurity technologies, adoption of AI, breakthroughs in quantum computing, market fragmentation caused by geopolitical developments

$590 billion–$1.2 trillion
Revenue in 2040

Batteries

Manufacturers of rechargeable batteries used for EVs and other technologies that are mostly linked to the energy transition

Growth factors
Improving energy density, price reduction as production capacity scales, increasing demand from EVs and battery energy storage systems

Dynamism factors
A few large players benefiting from advantages of scale, concentration of production in Asia–Pacific, policy incentives outside Asia to foster local battery supply chains

Swing factors
Innovations in battery technology, lower prices, localization of manufacturing, changes in regulation

$810 billion–$1.1 trillion

Revenue in 2040

Modular construction

Companies that operate in the modular construction value chain from design to assembly, with volumetric modules

Growth factors
Partnering across the value chain, selection of projects with consistent demand, successful on-site execution

Dynamism factors
Possibly a few large players if first movers achieve scale; regional and vertical fragmentation likely to persist given nature of construction industry, possible entry of large development companies

Swing factors
Ability to overcome industry inertia

$540 billion–$1.1 trillion

Revenue in 2040

Streaming video

Providers of on-demand video entertainment over the internet

Growth factors
Rising number of streaming households, especially in developing economies; increasing spending per household; increasing ad revenues from streaming

Dynamism factors
Benefits from scale and verticalization, moderated by regional players and new entrants benefiting from gen AI to create content

Swing factors
Evolution and role of user-generated content, adoption of advertiser-supported offerings, future platform bundles, relative success of subscription and ad-revenue-based models

$510 billion–$1.0 trillion

Revenue in 2040

Video games

Producers and distributors of games played on dedicated consoles, PCs, and mobile devices

Growth factors
Growing game-playing population and spending as a result of increasing global digitalization, growth of free-to-play games and microtransactions, user-generated content, cloud gaming, and increasing advertising revenue

Dynamism factors
A few large players in the console and PC market, along with vertical integration of console manufacturers into game publishing; high fragmentation in the mobile-game market

Swing factors
Mobile and casual gaming growth, internet expansion into emerging economies, and next-generation experiences, such as augmented and virtual reality

$550 billion–$910 billion
Revenue in 2040

Robotics

Manufacturers of robots and providers of robotics solutions

Growth factors
Continuing development of robotic technology to automate physical capabilities, increasing economic feasibility of solutions that drives adoption of general-purpose and trainable robotics, pace of mass adoption

Dynamism factors
Fragmentation in nascent specialized and autonomous general-purpose robotics industries, as well as a few players in traditional industrial market

Swing factors
New technologies that accelerate productivity, new use cases beyond current physical limitations of people, ability of robots to perform nonphysical labor such as caregiving, market fragmentation due to geopolitical developments

$190 billion–$910 billion
Revenue in 2040

Industrial and consumer biotech

Providers of biotechnology-enabled products in agriculture, alternative proteins, biomaterials and biochemicals, and consumer products markets

Growth factors
Commitments to decarbonization, new tech such as AI that expedites R&D, cost and quality of replacement product, efficient commercialization to scale from lab to mass production, public investments, consumer interest

Dynamism factors
High fragmentation given nascency, including small science-focused start-ups and large incumbents; a few large players may emerge if contenders scale and invest in R&D; fragmentation to remain if smaller players make easy breakthroughs

Swing factors
Pace of commercialization, competition with conventional consumer products, public concerns about privacy and genetic testing

$340 billion–$900 billion
Revenue in 2040

Future air mobility

Operators of air mobility transport services, such as eVTOLs and delivery drones

Growth factors
Improving battery and propulsion technologies, competitive pricing, regulatory and infrastructure support, addressing customer concerns over safety and price

Dynamism factors
Scaling of passenger eVTOLs may attract new entrants, but economies of scale and customer acquisition may restrict market to a few major players; a few major drone players likely to emerge regionally or globally

Swing factors
Regulatory framework to enable operations at scale, sustainability of business model, public attitudes on safety and convenience

$75 billion–$340 billion
Revenue in 2040

Drugs for obesity and related conditions

Companies that sell GLP-1s and other drug therapies for obesity and related conditions, such as diabetes

Growth factors
Growing incidence of obesity (25% by 2035), price reductions due to increasing competition and reduced manufacturing costs

Dynamism factors
A few large players likely to emerge from first movers, with potential fragmentation as other branded competitors and generics producers crop up

Swing factors
Potential for new innovations to treat other chronic diseases, global recognition of obesity as a disease, convenience and tolerability of drug delivery

$120 billion–$280 billion
Revenue in 2040

Nuclear fission power plants

Players that construct nuclear fission power generation facilities

Growth factors
Potential to lower construction costs through new technologies like small modular reactors, demand for baseload power to augment intermittent solar and wind generation, continued global commitments to decarbonization

Dynamism factors
A few large players given barriers to entry such as high R&D requirements; regional fragmentation driven by geopolitical scenarios; potential for new entrants if they can develop and scale next-generation technology

Swing factors
Global energy demand shifts, price of nuclear power compared to alternatives, public perception of safety, government support, pace of commercialization of next-generation technology

$65 billion–$150 billion
Revenue in 2040

Below we show how the potion ingredients—the key indicators that an arena may be forming—are already apparent in many cases, though depending on the arena's stage of development some may be harder to discern than others. The 18 arenas, sorted into continuing, spin-off, and emergent groups and ordered by the upper end of potential revenue ranges for 2040, are as follows:[32]

Continuing arenas

Four of our 12 current arenas—e-commerce, electric vehicles, cloud services, and semiconductors—are likely to become arenas of tomorrow. All four are in the middle phase of rapid growth in their S-curve of market adoption. Demand pools still have large headroom and could produce this growth, which is driven by the mega-forces of innovation and digitization.

E-commerce. This arena is continuing on the rapid phase of its S-curve of growth and is still anchored in the original business model step change, which was the online availability of retail sales. Nevertheless, other relevant business model resets could also spur growth in e-commerce, for example retail media networks, which are adjacent to the reset in another future arena, digital ads.[33] From mid-2020 to mid-2022, more than a dozen retailers debuted this new advertising revenue stream. Social commerce, which allows consumers to make purchases on social media apps, is another business model reset on the rise. In addition, e-commerce is expected to undergo more business model step changes by expanding further into large product categories such as healthcare and food.

Because e-commerce is a continuing arena, the escalatory investments in merchant and customer acquisition are likely to continue. Capital expenditures for last-mile delivery capabilities and investments in social media and payments integration are also likely to continue to escalate. A larger share of sales in developing markets and expansion into new product categories in developed markets are likely to sustain demand and drive the majority of e-commerce growth, effectively stretching this arena's S-curve.

Electric vehicles. EVs, an arena of today, are likely to continue to be an arena for two reasons: continued growth as EVs capture an increasing share of the large and stable demand for passenger and commercial vehicles, and the new rising competition in the industry. The breakthrough of battery cell technology and its current scalability and commercialization is the technology step change in this continuing arena. R&D investments could continue to escalate as players, especially traditional automotive incumbents, increase their share of EV sales. EV sales could eventually take the lion's share of overall passenger vehicle sales—in our estimates, from 18 percent in 2023 to between 82 and 96 percent by 2040.

Cloud services. The ongoing adoption of cloud services, a continuing arena of today, could generate $3 trillion of EBITDA increases for Forbes Global 2000 companies by 2030.[34] AI cloud represents a technological step change in this arena, because new AI models require significant amounts of computational power, which could be supported by cloud infrastructure. Furthermore, the types of infrastructure and platform services, including AI-enabled capabilities, that cloud providers offer will likely continue to evolve. New data sovereignty regulations, such as requirements about where data centers must be located, are also generating a step change in business models, fostering the emergence of regional competitors.

The escalation of capital expenditures is likely to continue as in past decades, and R&D expenditures could also escalate as players try to develop more efficient cloud infrastructure. We estimate that the share of global IT spending on cloud services could grow from 8 percent in 2022 to between 19 and 41 percent by 2040 as companies continue to migrate their computing and storage processes to the cloud.

Semiconductors. This current arena undergoes frequent technology step changes as manufacturers keep reducing the distance between chips' transistors and shrinking the size of components, including the transistors themselves. Players are likely to continue to escalate R&D and capital expenditures for machinery in pursuit of node resets, but also to meet rising demand for computational power. For example, the need for high-performance chips could keep growing as cloud services companies double down on investments in graphics processing units and AI accelerators for computationally intensive tasks.

Demand from four segments could drive the majority of the growth in semiconductors: computing and data storage, automotive, wireless communications, and industrial electronics. The requirements of AI and cloud services are likely to boost computing and data storage demand; driving assistance features, electric vehicles, and infotainment system components could propel automotive demand; the growing need for connected devices would increase wireless communications demand; and industries such as medical technology, automation, and electricity generation are likely to fuel industrial electronics demand.

Sidebar: How we defined the arenas of the future

As we explore a new set of arenas, it is worth revisiting the principles that guided our choice of the level of granularity we used to define them. Just as we did with our selection of arenas in chapters 1 and 2, we used supply-and-demand considerations to determine the granularity level for the arenas of tomorrow. The supply perspective determined whether the players and the competitive landscape were relatively well defined, with similarities in underlying technology or business models where step changes can spark escalatory competition, while the demand perspective ensured that products and services were sufficiently similar or substitutable. In some cases, defining arenas as broader industries was sufficient; in other cases, identifying these arenas involved splitting off a fast-growing portion of a large industry to analyze it on its own.

For example, we considered three future arenas that could have some overlap, particularly on the demand side: digital ads, streaming video, and video games. Each has large and fast-growing markets, distinct business models, and well-defined competitive landscapes. Some of these future arenas are subsets of current arenas (for example, the digital ads arena grew out of the consumer internet arena). While they could collectively be defined from the demand side as competing in the "attention economy," these arenas' products are related replacements but not direct substitutes for one another. From the supply side, the sets of companies that participate in each of the three arenas are generally distinct. For this reason, we analyzed them as three separate arenas, while recognizing that overall demand may shift between them over the coming decades.

The batteries arena has several subsegments, including batteries for EVs, battery energy storage systems, and batteries for consumer electronics. While each of these categories could have been analyzed as an independent arena, we looked to our supply-and-demand principles to help identify the reasonable level of granularity. On the supply side, all three subsegments have similar core technologies and participating players. And on the demand side, despite seemingly different end-use cases there is a similar need for stored energy. These characteristics are among the reasons we chose to define batteries as a single arena.

Spin-off arenas

Three arenas of today—consumer internet, software, and video and audio entertainment—have subsegments that may grow large enough and fast enough to become new arenas. The consumer internet arena of today could spin off a digital advertisement arena; the software arena of today could generate an AI software and services arena; and the video and audio entertainment arena of today could spawn a streaming video arena. From an S-curve perspective, a specific technological or business model step change helped separate these subsegments, now potential arenas of tomorrow, into their own new S-curves. For example, growth in the broader software industry is likely to slow as it approaches the tail end of its S-curve of adoption and innovation. AI, however, is disrupting the industry and leading to a new S-curve. This new S-curve is specific to AI software and services and could demonstrate its own explosive growth in the next few years, as is typical in the early stages of an S-curve.

AI software and services. Although some types of AI, such as machine learning, have been around for decades, the technology rose to public prominence in late 2022 with the release of OpenAI's ChatGPT, a gen AI interface capable of producing remarkably humanlike responses to users' prompts. The recent emergence of gen AI is the technological step change in this market that supports our definition of AI software and services as its own arena, making it a spin-off of software as an arena of today. Cloud services, a continuing arena, is also critical for AI software and services, because it enables most of the computational processing required by today's AI models. And there are signs of momentum for adoption that indicate the beginnings of a new S-curve: in an April 2023 McKinsey survey, nearly a third of respondents said their organizations were using gen AI in at least one business function, and 40 percent said their organizations would increase AI investments.[35] In March 2024, two-thirds of the survey's respondents reported that their organizations were using gen AI, doubling the level of adoption in less than one year.[36]

Players are escalating R&D investments in this arena as they attempt to differentiate their services through advanced capabilities. AI systems, such as GPT-4 by OpenAI and Gemini by Google, that compete in the "frontier" foundation models segment—that is, the biggest, most advanced models—escalate investments in proprietary data and infrastructure to create industry-leading models. Players that compete in the fragmented specialized AI software segment (such as AI start-ups that have specific use cases) escalate investments by creating bespoke AI-enabled systems tailored to their use cases. This arena's potential economic impact and the associated revenue could be significant as a result of a large market for both consumer as well as corporate use cases, such as consumer research and segmentation, software engineering, and operations.

Digital advertising. More people online, a rising middle class (just ten countries could add 900 million people to the middle class by 2030), and more time spent on digital media (in the United States, from 40 percent in 2016 to 66 percent in 2026, according to forecasts)[37] are continuing to increase the demand pool for digital advertising, which funds much of the internet through search, social, and media. Players are continuously experimenting with business models to attract users. For example, media players are trying out different ad-supported tiers, as well as the formats of advertisements, such as in-line ads in social media posts or ads displayed as part of a gen AI search query result.[38] Technology in the industry also is moving quickly, with new players introducing new experiences such as short-form social videos or building capabilities to hyper-target customers and track the cost-effectiveness of advertisements, and increasing the use of gen AI for hyper-personalization and to lower the cost of content creation.

Investments escalate as players attempt to sustain a leading edge in an environment with strong network effects. Players are locked in a battle for attention across platforms and must continuously invest to create the most engaging experience, biggest social network, or best media content to keep people—and the advertisers that want to reach them—on their platforms. Players must also invest

to capture new pockets of growth, especially in developing economies, where regional competitors can emerge to challenge global leaders. We expect digital ads to capture a growing share of global ad spending, from 65 percent in 2022 to between 80 and 90 percent by 2040.

Streaming video. The video and audio entertainment arena could be transformed because the streaming technology developed in the past 15 years is being adopted more rapidly, resulting in a new spin-off arena: streaming video. The uptake of streaming video is still in the steep part of its S-curve. In the past, investments for customer acquisition and content production escalated as competition intensified between players. However, companies now face pressure to increase profitability. As a consequence, investments will be made in partnerships and other collaborative models, such as content bundling. The two-way network effect in this arena will likely persist: more content attracts viewers, and more viewers give platforms more leverage to license content or revenues to produce their own.

The market for streaming video may also be buoyed by demand from increasing high-speed internet access in developing economies as more households around the world gain the ability to stream video online. This larger customer base would also increase the potential revenues earned from advertising on these platforms.

Emergent arenas

The remaining 11 potential arenas of tomorrow, the emergent arenas, are generally novel relative to existing industries. In other words, they are not clear subsegments, though some of their enabling technologies may be similar to those that enable other industries or arenas. These potential arenas vary in degree of maturity, a natural consequence of using 2022 as the starting point of our analysis. Some of these potential arenas, such as video games, have existed for decades, while others, such as drugs for obesity and related conditions, are in very early stages of formation. For all of them, however, there is high growth and high dynamism potential because these arenas are in the early to middle phases of their S-curves.

Shared autonomous vehicles (SAVs). The development of technology for vehicle autonomy (integration of computer vision, real-time machine learning, and large-scale data engineering, such as high-resolution mapping) is the step change in this arena, where R&D investments escalate primarily to overcome technological obstacles that affect the cars' safety and reliability. Despite the increased prevalence of vehicles for hire that don't require a human driver, a recent decline in SAV investment suggests that commercialization may go more slowly than forecast. The large market for SAVs could depend on regulation, technological progress, financial feasibility, and consumer adoption of the vehicles.[39] We estimate that SAVs could capture 25 to 51 percent of the shared mobility industry's revenues by 2040.

Space. The commercial sector of the space arena has shown robust growth and accelerating market activity in the past decade, with recent players, such as SpaceX, Blue Origin, and Virgin Galactic, entering the fray. Government interest has also evolved: the number of government space agencies around the world has grown from 40 in 2000 to more than 75 today.[40] This arena experiences frequent technological step changes, especially in the form of commercially viable spacecraft and new satellite systems, like SpaceX's Starlink system. Innovations in launch mechanisms, such as reusable boosters, are also under way.

Escalation in R&D has occurred in both the public and private sectors. Major players continue to double down on investments for new product launches. Private-sector spending in space is reaching all-time highs, with more than $70 billion invested in 2021 and 2022 combined.[41]

Growth in the space arena may be driven by state-sponsored investments in the civil and defense segments; consumer needs for space capabilities, such as communications and navigation; and commercial infrastructure and support operations required to meet these state-sponsored and consumer demands.

Cybersecurity. In 2020, the global direct financial damage from cybercrime was estimated at about $950 billion, almost twice the $520 billion recorded in 2018. When considering direct, indirect, and upstream systemic costs, the overall economic impact of cybercrime in 2020 was estimated to reach approximately $4 trillion to $6 trillion, or more than 4 percent of global GDP and more than four times the direct costs.[42] As adversarial parties keep improving their capabilities, selling ransomware-as-a-service, and creating marketplaces for hacking tools and data, players in this arena need to continuously improve their offerings to protect computer systems from unauthorized access by adversaries. The cybersecurity technological step change is the data protection and network security that complements other fast-growing technologies with new vulnerabilities.

As a result, R&D investments escalate for the development of more effective products and services. This often includes investing in proprietary data sets and processing power, which are frequently needed for AI use cases. Innovation in the industry has been expanding, too, with the number of patents growing at rates of 10 to 25 percent from 2017 to 2021. As attacks continue to increase and the digital landscape grows and changes, cybersecurity spending is expected to represent a larger share of global IT spending, from 6 percent in 2022 to between 7 and 14 percent by 2040.

Batteries. The global energy transition is fueling demand for batteries, mainly due to the continued growth of EVs, battery energy storage systems, and consumer electronics. Manufacturers of batteries have made technological step changes related to energy density, charging speed, longer life cycles, and manufacturing sustainability.

R&D is likely to escalate as manufacturers innovate on battery technologies, such as enriching the anode with silicon compounds. Manufacturers also are innovating in new designs such as solid-state and new chemistries such as lithium-sulfur and vanadium redox, which could become direct substitutes for lithium-ion and sodium-ion batteries in specific applications. Capital expenditures could escalate as players try to capture the benefits of manufacturing at scale, as seen in the rise of gigafactories. As a result, barriers to entry could rise for new entrants, improving the margins of large incumbents.

Video games. The rise of mobile and cloud gaming, which allow games to be delivered faster through new platforms, served as a technology step change in this arena.[43] This coincides with a business model step change, with free-to-play games like Fortnite aiming for wider distribution and to generate revenue through in-game purchases. R&D investments, especially in game development, have escalated in this arena. For example, several high-profile AAA games are released each year.[44] These games have budgets of at least $200 million, more than the average production budget of the 150 most expensive movies from 2016 to 2023, $180 million.

The surge in mobile gaming and the success of the free-to-play in-game-purchase business model on various platforms drive this large and growing market. Growing consumer spending on games, as well as higher advertising revenue and console sales, are expected to increase revenues despite recent setbacks in certain markets, such as below-expectations revenue growth and consumer spending that returned to prepandemic levels.

Robotics. Advancements in the autonomous-robot segment represent a major technological reset by helping to improve the mobility and dexterity of the machines and increase the range of tasks they can perform easily. One way to understand this arena is through robot types, from single-purpose robots typically used in industrial or manufacturing environments to general-purpose robots, which are more recent and can execute a variety of tasks with limited human intervention. Boston

Dynamics, Tesla, Figure, Google, and Sanctuary are among the players trying to develop general-purpose robots to take on tasks currently performed by humans.

R&D investments may escalate, especially in the subsectors of general-purpose robots and specialized robots for specific use cases, such as cooking or packing boxes. Players are intensifying an already heavy R&D focus on deep technology as they vie for share. Acquisitions and investments in robotics companies are also escalating. The robotics arena received a growing influx of capital, with venture capital investment increasing from about $4.6 billion in 2018 to about $13 billion in 2022.

Industrial and consumer biotechnology. The technology step change in this arena is attributable to breakthrough biological innovations, such as the decline in the cost of reading genetic codes and the improvement in the capability to edit genes using CRISPR technology. As a result, application of this technology may accelerate in four areas: agricultural biotechnology (such as bioengineered crops), alternative proteins (such as cell-based meats), consumer products and services (such as personalized wellness products), and biomaterials and biochemicals (such as bioplastics).

R&D and capital expenditures account for the majority of the escalatory investments for product development, commercialization, and manufacturing needs. The large and growing market in the industrial and commercial biotechnology arena may be driven by several factors, including advancements in technology facilitating R&D, increasing consumer demand, the commercialization of new products and services, and regulatory and consumer commitments to sustainability.

Modular construction. These are builders in the housing market that produce standardized, prefabricated modules made at an off-site factory and then assembled into buildings. This method can improve construction productivity amid lagging labor productivity growth in the gigantic $13 trillion global construction industry. Improving construction productivity is urgent to address an ongoing global housing shortage and affordability crisis, as well as a critical skilled labor gap in the construction industry.

The modular, prefabricated process that enables the parallelization of construction phases is the business model reset in this arena and could greatly improve construction productivity. While some modular construction is widespread in a few high labor-cost countries like Japan, the Nordics, and Singapore, global penetration is still relatively low.

However, there are signs that broader adoption—the rising part of the S-curve—could be near. There is increasing investment and research into processes and digital tools that can help players solve the complex value chain coordination challenges of modular construction. And growth in modular has the potential for a flywheel effect. As more buildings are built using modular techniques, the supply of modular increases, which in turn makes it more likely that other developers could choose modular as well.

Nuclear fission power plants. Today, nuclear fission reactors are the second-largest source of electricity generated with low emissions of greenhouse gases, after hydropower. In this arena, we look at players that build nuclear power generation facilities. The next generation of small modular reactors is an example of a technological step change because the reactors are designed to be both safer than traditional large-scale reactors and cheaper to build by using prefabricated components and standardized designs. As more countries build nuclear power plants and the global market grows, learning curve efficiencies could push down this capital expenditure for both large-scale reactors and SMRs.

R&D investments could escalate in the race to reduce building costs and develop new reactor technologies, construction methods, and coolant types. Global venture investment funders seem optimistic about this arena despite the high capital costs and the long time horizon before returns are realized. Funding rose from about $60 million in 2018 to about $390 million in 2022. To reach

emissions-reduction targets, countries would likely need to rely on nuclear power to complement intermittent renewable energy sources, such as wind and solar. China, Russia, South Korea, and other countries plan to significantly scale up nuclear power production. At the COP28 climate conference in 2023, 25 countries pledged to triple their nuclear energy capacity by 2050 to reduce emissions.

Future air mobility. Innovations in materials, propulsion, batteries, and autonomous technology for passenger electric vertical takeoff and landing vehicles (eVTOLs) and delivery drones are the technological step changes in this arena. R&D investments in these components could continue to increase as air mobility technologies begin to reach commercialization. The need for "vertiport" boarding and landing facilities, as well as delivery distribution centers, means capital expenditures may also increase. While many of these nascent technologies are yet to be commercially available, there are early signs of future growth: disclosed annual funding for this arena grew from less than $600 million in 2017 to $5 billion in 2023 as companies progressed on their regulatory and certification journeys and aimed to tap the large addressable markets for new modes of transportation.

Drugs for obesity and related conditions. A report by the World Obesity Atlas estimates that obesity prevalence could rise from 14 percent in 2020 to 24 percent by 2035, based on current trajectories, with an attributable economic impact of $2.0 trillion in 2020 and $4.3 trillion in 2035.[45] The technology step change in this arena was the introduction of GLP-1 agonists, a revolutionary class of drugs that were initially approved to treat diabetes and, more recently, obesity as well.

An escalatory dynamic is evident in the R&D race, as major players develop their own GLP-1 weight-loss therapies. With generics on the horizon, players are incentivized to further invest in R&D for more efficacious drugs with fewer adverse effects or more convenient drug administration like an oral solid pill, rather than the current injectables.

Other candidate arenas

In determining potential future arenas, we considered new industries that could eventually become arenas but are less likely than some other industries to achieve the high growth and high dynamism of our arenas of tomorrow. We discuss them briefly below, with an emphasis on swing factors that could make them arenas.[46] We consider two other groups of industries: the ceasing arenas—arenas of today that are unlikely to persist as arenas of tomorrow—and the almost emergent arenas, which have uncertain growth or dynamism prospects.

Ceasing arenas

Five arenas of today—biopharmaceuticals, consumer electronics, information-enabled business services, industrial electronics, and payments—are likely to cease to be arenas. This does not mean these industries will not see high growth or high dynamism; they remain critical to today's economy. However, growth or dynamism may not be at the same scale as in the past 15 years. These arenas are hitting the plateauing phase of their S-curves. Many are likely to continue to benefit from a mega-force like payments taking advantage of digitization opportunities in emerging markets, or biopharmaceuticals serving a more prosperous world. However, the growth of these current arenas is likely to be more stable than explosive.

Biopharmaceuticals. The distinction between biopharmaceuticals and their traditional pharmaceutical counterparts is becoming irrelevant. As it is, players are already incorporating both into their product lines as effective drugs for targeted treatments, combination therapies, or both. As a result, biopharmaceuticals, which have been disruptive in the past, are already mainstream. There is also a weak case for vulnerability or obsolescence of the traditional pharmaceuticals industry.

Both biopharmaceuticals and traditional pharmaceuticals could see breakthroughs that spur the high growth and dynamism required of an arena beyond those achieved in the treatment of obesity and related conditions (already a potential future arena). These advancements could occur in oncology research, neuroscience, immunology, or gene therapy, among other fields.

Consumer electronics. Established players, such as Apple and Samsung, are likely to drive growth in this industry over the next few years as demand remains robust. However, growth may not be of the same magnitude as before. Some estimates indicate that the consumer electronics industry could grow at a 3 percent rate from 2024 to 2028, a lower pace than the 7 percent observed in this arena from 2005 to 2020.[47] This slower growth could result from plateauing of smartphone adoption globally. It is also possible that market leaders could maintain intensifying and stable market share competition over the next few years, making the dynamism prospects of this arena uncertain.

Information-enabled business services. Most of the growth from knowledge and business process outsourcing as a result of globalization and digitization has likely already been captured, and greater stability is expected as large incumbents buttress their market positions.

Industrial electronics. This arena has already captured large pockets of growth, including in China. While growth may reach about 6 percent through 2030, it most likely will not be at the same pace as before, a slowdown that could be similar to the likely gradual plateauing of the consumer electronics arena.[48]

Payments. For established payment use cases, such as high-frequency and small-ticket transactions, the expansion of payments brought about by digitization was mostly captured in the past decade. That gave current players a strong hold on market shares but will likely result in this arena's reduced growth or dynamism prospects compared with the past two decades. However, opportunity for some growth remains. Players could enter the market and innovate solutions for low-frequency but large-size transactions, such as tuition and business services like home repair. Regional players could emerge in developing markets, which could lead to new growth.

Almost-emergent arenas

These candidate arenas were not analyzed as deeply as our 18 arenas of tomorrow described above. Some of these potential arenas, such as Web3, were not included primarily because of high uncertainty about their growth or dynamism prospects. Others have a more certain rising trajectory but a lower probability of evolving into arenas compared with the 18 we analyzed. Nonetheless, we have chosen to discuss them below because each has exciting potential and we recognize the possibility that these industries could still become arenas—we want to leave plenty of room for the eventuality that things could turn out differently from expectations. These candidate arenas are as follows, ordered alphabetically:

Clean hydrogen. This industry consists of companies that provide energy through low-carbon hydrogen, including from natural gas, known as blue hydrogen, as well as renewable hydrogen from electrolysis powered by renewables, known as green hydrogen. The current use cases, mostly for industrial processes like oil refining, required approximately 90 million tons of hydrogen in 2022.[49] The share of clean hydrogen in current hydrogen consumption is negligible, at less than one million tons.

The new industry of producing low-emission hydrogen is already encountering regulatory tailwinds. For example, in 2023, the EU Hydrogen Bank, backed by a $3.3 billion investment from the EU Innovation Fund, held its first EU-wide auction for renewable hydrogen producers that wished to receive support. The auction attracted 132 bids from 17 countries.[50] In February 2024, Germany allocated €3.5 billion in subsidies to support green hydrogen exporters through H2Global.[51] The US Department of Energy has announced a $7 billion investment to launch seven regional clean hydrogen hubs.[52]

Existing demand for industrial use cases is expected to be stable, increasing from about 86 metric tons in 2020 to 111 metric tons in 2040, but new pockets of demand will likely come from new industrial use cases such as green steel or grid-level storage. However, there is considerable uncertainty about the uptake of hydrogen in industrial processes or emerging use cases. This uncertainty stems from factors including an evolving regulatory climate, the development of enabling technology and specialized infrastructure, competition dynamics with other decarbonization technologies, and potential adoption barriers like distribution and delivery costs.

Lower-carbon materials. This industry consists of manufacturers of low-carbon materials, of which steel, cement, and aluminum are most relevant for decarbonization (low-carbon bioplastics are discussed in the industrial and consumer biotechnology compendium entry). These three materials have varying starting points and face their own challenges as decarbonization continues. The industry could undergo a big shift enabled by potential technological breakthroughs to decarbonize the manufacturing process achieved by the use of electrification, circularity, carbon capture storage, or low-emission fuels such as biomass. Today, about $6 billion of revenues are generated from the sale of lower-carbon ("green") materials. This figure could grow to hundreds of billions by 2040. Green steel will likely be the largest component of this growth, contributing about half of the revenues. Projections are highly sensitive to future price fluctuations in the materials industry.

The lower-carbon materials industry has the potential for high dynamism. The acceleration of steel decarbonization may entail a reconfiguration of the value chain as energy-intensive production steps such as direct iron reduction locate closer to sources of clean energy, a requirement for the decarbonization process. While this would imply large investments, it also opens up opportunities as more geographies become attractive as locations for new plants. The massive energy requirements of green steel manufacturing may require new capacity in regions with lower energy costs like Brazil, the Middle East and North Africa, and countries like Spain.[53] Many, if not all, incumbent steel players have decarbonization projects under development or in implementation. Meanwhile, new players like H2 Green Steel have started making moves aimed at building a large-scale green steel plant that would start production as early as March 2026.[54]

However, green steel's growth is uncertain for two reasons. First, global demand for steel may be reduced by an unevenly distributed slowdown across regions and industries over the next few years. The shifts that could cause this uncertainty include the "normalization" of demand in China, which may be partially offset by growth in Southeast Asia and India, and the slowdown in construction demand, which may be offset by growth in energy and transportation.[55] Second, there is uncertainty about how rapidly green steel could replace traditional steel. This is mostly due to the competitiveness of green steel manufacturing costs compared with traditional steel. The cost could be affected by several factors, including regulatory support, capital investments, manufacturing technology advancements, raw energy costs, and value chain reconfigurations. Despite this industry's potential high dynamism and large shifts, the growth uncertainty diminishes the likelihood that low-carbon materials could reach arena status.

Products and services for older adults. Companies in these industries offer services to meet the needs of adults aged 65 and older. By 2050, there could be 1.6 billion people in this demographic. In 2022, there were, on average, seven working people for every person over 65 (also known as the old-age dependency ratio). By 2040, that ratio could shrink to four to one, creating a shortage of caregivers.

Today, an estimated $13 trillion is being spent on and by older people, with housing, health, and wellness the biggest drivers. Traditional players participate in select parts of elder care services, including nursing homes that provide housing and meet care needs, and financial institutions that provide retirement and pension management and other services. Only a few of the players we

considered provide holistic, seamless services. At the same time, older adults' needs like health, connection, autonomy, and security are not always fully met in this rapidly changing environment.

Some early platform plays are surfacing today: JD.com is investing in a care ecosystem for older people through partnerships, telehealth product launches, and healthcare management products. Clariane Group, a nursing care provider, acquired 32 companies in 2019 and 2020 to create a digital ecosystem for home care professionals and care facility residents.[56] A truly digital and comprehensive ecosystem by 2040 would require technological step changes, such as the automation of caregiving, and coordinated innovation among tech players, property developers, healthcare providers, and financial services players. Sufficient early signs of these breakthroughs and innovations have yet to be observed at a level that could ignite an arena.

Aside from these technological uncertainties, it is also likely that the industry will remain fragmented if global or even national plays are discouraged by limited economies of scale, market regulations, cultural differences, and the way services are delivered. For these reasons, even though this industry is likely to see major growth as populations age, there may be limited dynamism as players remain small and local, making products and services for older adults less likely to be an arena of tomorrow.

Nuclear fusion. This industry consists of companies that build plants able to generate electricity through nuclear fusion. More than 130 experimental fusion devices are operating, under construction, or planned around the world today.[57] While the technology is still in the experimental phase, fusion has the potential to become the world's zero-emissions power source, promising cheap and abundant clean energy that could transform the world.

Yet even though the technology is promising, uncertainty about the rate of technological progression is the primary swing factor determining whether nuclear fusion could become an arena. It is unlikely that a commercially scalable and sizable industry could be formed by 2040, even in the best-case scenario of a major scientific breakthrough as early as 2030. Several technical challenges must be overcome before a fusion reactor can become commercially viable: magnet performance, survivability of the first wall, plasma stability in confinement concepts other than tokamaks, and reliable heating systems.[58] Massive R&D investments, supply chain advancements, talent sourcing, and partnerships to develop regulation would all be needed and would take a long time to scale up. For these reasons, nuclear fusion has a relatively low probability of sufficient growth to become an arena by 2040.

Renewables generation equipment and infrastructure. These are companies that manufacture equipment for renewable energy generation (wind and solar), storage for renewable energy, and transmission and distribution infrastructure. The potential growth in this industry is driven by the continued push for decarbonization. Many governments have committed to net-zero targets, and several technological advancements in renewable generation in the past decade drove production and cost efficiencies. Solar and wind power have both become cost competitive with fossil-fuel-based power sources in the past decade.[59] Global investment in renewable energy rose to $358 billion in the first half of 2023, an all-time high for a six-month period.

This industry is likely to see higher growth in the earlier phase of our time horizon, until 2030, but more modest growth from 2030 to 2040. Three compounding swing factors may change this estimate. The first is the pace of energy consumption growth, which could be influenced by population growth, industrial needs, and EV adoption, among other factors. Second is the ability of the renewables sector to capture a material share of this growth, which would require simultaneous investments in steps from generation to distribution. Third, uncertainty about the pace of technology advances and affordability translates to uncertainty about the total investment and timing of the peak expenditure in this sector.

While renewables generation is likely to take an increasing share of global electricity production, the industry's growth trajectory to 2040 is uncertain, especially if peak expenditure occurs before then and growth from new installs slows. The industry could also see low dynamism as high barriers to entry favor incumbents. These factors make renewables generation equipment and infrastructure an almost emergent arena with a promising trajectory but also relatively lower likelihood of becoming an arena of tomorrow.

Sustainable fuels. This industry consists of companies that use sources other than fossils to make liquid fuels for transportation, primarily for cars, trucks, aviation, and marine. Over their lifetimes—that is, from when they are produced to when they are burned in vehicles—sustainable fuels typically emit fewer greenhouse gases than fossil fuels.

There are three kinds of sustainable fuel. First are conventional biofuels, made from raw materials that are edible, such as sugars and starches derived from corn or sugarcane, or from oils derived from sunflower or rapeseed. These mostly alcohol- and ester-based fuels need to be blended with traditional fossil fuels to be used in a typical internal combustion engine, which is why they are called "blend-in" fuels. Second are advanced biofuels made from raw materials that are not used for food, including agricultural residue, dedicated crops, and waste. These fuels, called "drop-in" fuels, are chemically similar to gasoline and can be used without blending with traditional fossil fuels. The third kind is e-fuels, made by breaking down water into hydrogen and oxygen, typically by combining the hydrogen with carbon.

There is potential for sustainable fuels to grow to arena status by 2040 if the industry captures a large enough share of the fuels market. However, great uncertainty surrounds the industry's growth prospects because of the challenges that would need to be overcome to reach scale, such as customers' willingness to pay a green premium for sustainable fuels, and how much the trajectory of electrified mobility will affect global fuel demand. Further, degrees of fragmentation vary among players in the three segments of sustainable fuels. For example, drop-in fuels are likely to have a few large producers, whereas the supplier base for blend-in fuels and e-fuels is highly fragmented. These uncertainties make it hard to assert that sustainable fuels are a likely arena of tomorrow, though they have that potential.

Virtual reality and augmented reality (VR and AR). This industry consists of players that manufacture the hardware required for VR and AR, and players that provide the software operated on this hardware. VR and AR companies enable customers to immerse themselves in virtual worlds where users are "in" the experience rather than merely observing it. The VR and AR industry had estimated revenues of $22 billion in 2022 from hardware and software sales.[60] About $30 billion in venture capital flows went to VR and AR from 2020 to 2023.

VR and AR can be applied for both consumer and commercial use cases. For consumers, the metaverse is an example of the extended application of VR and AR (although the metaverse can also be accessed through conventional interfaces, such as phones and laptops). Corporate use cases range from healthcare applications, such as 3D body mapping, to retail, such as trying on clothing and experimenting with furniture placement in a room, to education and training, such as VR-assisted instruction for machinery-intensive jobs.

While the potential technological step changes in this industry are clear in both the innovative hardware and the accompanying software that enable the VR and AR experience, it is uncertain whether the escalatory dynamic in investments and addressable market are sufficient to develop the growth and dynamism features required of an arena by 2040. Two mutually reinforcing swing factors may determine the future of this industry. First, there will likely need to be substantial step changes in the technology, particularly in lighter-weight headsets that do not have to be tethered for power and do not cause nausea in a substantial set of users. Second, the industry would require widespread

adoption of the technology and software platforms for new use cases. If the technology performs well enough to encourage adoption, that could spur more investments to improve the technology. If these two factors create a virtuous cycle, the VR and AR industry could be an arena by 2040.

Web3, including decentralized finance. Web3 is the idea of a new, decentralized internet built on blockchains, which are distributed ledgers controlled communally by participants. Web3 has the potential to change how information is managed, how the internet is monetized, and even how web-based corporations function. Most of the potential growth could come from financial use cases related to tokenization, trading, payments, decentralized finance, and custody. However, some areas of Web3 have seen downturns as others continue to soar. For example, the crypto market's market capitalization fell more than 50 percent in 2022, while there was a 68 percent increase in nonfungible token sales in the same year.[61] Technology adoption also seems to have advanced: as of 2023, there were thousands of decentralized applications running, compared with about 1,000 in 2018.[62]

This is a nascent industry that is shifting rapidly and faces several obstacles, mainly related to the need for clarity in regulations regarding asset classification, tax reporting, and know your customer (KYC) standards. However, there has already been significant regulatory activity. For instance, the US Congress proposed more than 50 crypto regulations in 2022.[63] Technical obstacles, including privacy concerns, have arisen because blockchains are public by design, which limits potential use cases. Other obstacles include the risk of fraud, high transaction costs, and services that are sensitive to failure.[64]

Web3 is still in its infancy and could transform the way we execute transactions, run applications, and own assets. However, there are major uncertainties on the path toward adoption that could influence the development of the ecosystem and which players could be active in it. As a result of this great uncertainty, it is hard to estimate whether Web3 would display the revenue growth and competitive dynamism to qualify as an arena of 2040.

Geopolitical disruption, the development of AI, and the pace of the green transition could be critical swing factors.

The significance of potential future arenas

In chapters 1 and 2 we demonstrated that the 12 arenas of today are not only centers of value creation but also industries that materially change the way we live. Our 18 arenas of tomorrow could be even more transformative, as they could shape how we consume and process data, approach health and wellness, and interact and communicate with one another. Innovations in areas such as robotics, mobility, AI, and clean energy may play a growing part in expanding the choices available to us in our daily lives.

We may soon be able to take an eVTOL from our local vertiport instead of ordering an Uber. We may have AI virtual assistants to help us finish writing emails or plan our vacations. We may have the option to commute to work in a shared ride in an autonomous shuttle instead of driving our own car. Homeowners may be able to store renewable electricity in their EV batteries and use those batteries to buy electricity when prices are low and to sell it back to the grid when prices are high. A wide variety of robots may come to assist us with physical labor, speeding up task times in agriculture or construction.

But also, looking back to 2005, we recognize cause for humility. No one could have predicted all of the ways in which the arenas of today have evolved. Therefore, we also highlight some critical swing factors that go beyond uncertainties in the modeling and are more fundamental to the evolution of the arenas of tomorrow in technology, investment patterns, and sources of demand. Many of these factors are specific to individual arenas and are described in the compendium at the end of this report, but looking across arenas, we see the following three themes:[65]

Developments in geopolitics: Geopolitical events affect many arenas. Swing factors include the possibility that technology stacks could diverge across regions, with different groups of countries pursuing technologies in parallel, such as in AI if government actions create multiple geographically distinct ecosystems. And technology players could be affected by geopolitical changes that create turbulence in trade flows and markets. It also remains to be seen whether the internet could become more regional, and the impact that could have on cybersecurity, cloud services, and other industries.

While geopolitical developments could affect the growth of many arenas, they will have an even greater impact on dynamism by defining who the players are and where they are allowed to play. Geopolitical splintering and disruption would be particularly relevant to the following arenas: cybersecurity, robotics, AI, cloud services, space, EVs, batteries, semiconductors, e-commerce, and digital advertisements.

Development and adoption of AI technology: AI software and services is an arena, and the evolution of artificial intelligence, especially gen AI, could fundamentally change the shape of several other arenas over the coming decades. New capabilities enabled by gen AI could lower the cost of creative content used in digital ads, create storylines for immersive video games, give robots lifelike personalities, or change the way consumers find products and services on search platforms. But much will depend on the pace of AI adoption, how quickly use cases come online, and the value of the productivity gains from using the technology.

In addition, the adoption of automation could be sharply accelerated. Without gen AI, automation could take over tasks accounting for 22 percent of the hours worked in the US economy by 2030, according to our estimates. With gen AI, that share could jump to 30 percent.[66] The trajectory of AI development could affect all 18 arenas but is especially relevant to video games, streaming video, digital ads, cloud services, cybersecurity, e-commerce, semiconductors, robotics, industrial and consumer biotechnology, and SAVs. The technology still faces technological hurdles before full deployment, including gen AI's factual accuracy and safety concerns over privacy and misuse.

Pace of the green transition: Global efforts to alter the course of climate change by reducing CO_2 emissions[67] could drive demand in many of the 18 potential arenas of tomorrow (and determine whether as many as five of the eight almost emergent arenas become arenas). Often, their potential revenue size depends substantially on how much of a priority governments, consumers, and businesses place on carbon emissions reductions and how much they're willing to pay to abate them in cost, time, or convenience. For example, if countries remain committed to clean energy targets, they will likely require some nuclear fission power production to balance dips in solar and wind generation. If emission reductions become a lower political priority, countries could have a much broader range of options to meet their energy needs. The robustness of decarbonization targets and the commitments people and governments make to achieve them will likely have a major impact on the future market size of EVs, batteries, nuclear fission power plants, industrial and consumer biotechnology, and modular construction.

As the direction of these swing factors becomes clear, so too will the trajectory of our growth and dynamism scenarios. Our research provides an initial view of where to expect the most growth and dynamism and how to update that view as the future takes shape.

Analyzing the trajectories of the potential 18 arenas of tomorrow surfaces critical questions, from the ethics underpinning data and privacy to imperatives for businesses to be inclusive and sustainable. While arenas' precise trajectories are difficult to predict, economic and social disruptions are natural consequences as these industries form, grow, and impact the world. Recognizing how and when arenas originate, understanding how they evolve, and anticipating the way they impact the world can offer a unique view of the arc of society's progress.

To give more insight into the economics of arenas, we present a compendium of the 18 future arenas and discuss in detail how high growth and high dynamism might play out in each. These descriptions should not be read as comprehensive accounts. Instead, they explain a rationale for a range of scenarios for growth and dynamism over the coming decades and describe some swing factors that could alter the outcomes.

Arenas of tomorrow compendium

1. E-commerce

2. Artificial intelligence software and services

3. Cloud services

4. Electric vehicles

5. Digital advertisements

6. Semiconductors

7. Shared autonomous vehicles

8. Space

9. Cybersecurity

10. Batteries

11. Modular construction

12. Streaming video

13. Video games

14. Robotics

15. Industrial and consumer biotechnology

16. Future air mobility

17. Drugs for obesity and related conditions

18. Nuclear fission power plants

Contributing author:
Roberto Longo

1. E-commerce

The e-commerce industry consists of companies that sell goods to consumers through digital channels. This industry is already well established, its rise fueled by the spread of broadband internet access, increasing ways to access the internet (especially smartphones), and innovations in product delivery, including on-demand warehousing, last-mile delivery, increased automation, and crowdsourced delivery methods.[68]

E-commerce is one of today's arenas, as we describe in chapter 1, and there are many reasons to believe that it could be one of tomorrow's, too. In 2022, the retail e-commerce segment accounted for 20 percent of a $17 trillion overall global retail market, leaving plenty of room for further expansion in both geography and product categories. Online markets in China, Latin America, and other developing economies are likely to continue to grow as digitization increases. And e-commerce is expected to continue to expand into new major product categories, such as personal care and food. Social commerce, or making purchases on social media apps, is also on the rise.[69]

Growth

We define e-commerce as completing purchases on computers and mobile devices, including selling and buying items that consumers pick up at brick-and-mortar stores. This definition encompasses revenue from manufacturers with direct-to-consumer (DTC) channels, platform providers such as Amazon that have marketplaces for third-party retailers, third-party retailers (known as merchants) when they sell on platforms such as Amazon, and traditional retailers with online channels. This excludes several industry-adjacent markets, including peer-to-peer or consumer-to-consumer (C2C) sales, such as those available on Facebook Marketplace, and ride-hailing and streaming services.

Our overall sizing of the industry has two main segments: retail e-commerce and food e-commerce (shipping costs excluded). The retail e-commerce segment includes categories of consumer goods such as general merchandise, apparel, and appliances.[70] Together, the revenues of the two segments reached roughly $4 trillion in 2022. That could grow to between $14 trillion and $20 trillion by 2040, a CAGR of 7 to 9 percent.[71]

The retail e-commerce segment currently accounts for one-fifth of global retail revenues (both online and offline), and that share could reach 27 to 38 percent by 2040. In our estimates, revenues could grow from $3.4 trillion in 2022 to $11 trillion by 2040 in the lower range of scenarios and to $16 trillion in the higher range of scenarios. Meanwhile, the food e-commerce segment brings in $630 billion in revenues today, or 4 percent of global retail revenues. That could grow to $3 trillion by 2040 in the lower range of scenarios and to $4 trillion in the higher range of scenarios, or 7 to 9 percent of global retail revenues.

Retail e-commerce could come to represent a larger overall share of total retail sales in developing economies, where it is now less prevalent than in developed economies. For example, in 2022, its share of retail sales was just 12 percent in Latin America, 4 percent in the Middle East, and 2 percent in Africa. The lower range of scenarios assumes that retail e-commerce could account for 26 percent of retail revenues in Latin America by 2040, 15 percent in the Middle East, and 10 percent in Africa. In the higher range of scenarios, Latin America's share increases to 29 percent, the Middle East's to 20 percent, and Africa's to 15 percent.

E-commerce in those markets could grow with the expansion of the middle class, increased access to broadband, and the development of infrastructure and services, such as last-mile delivery, that enable sales. For example, smartphone penetration in India grew from 26 percent in 2018 to 36 percent in 2022 and is expected to reach 56 percent by 2027. In sub-Saharan Africa, the

*Note: This section describes the potential growth and dynamism of the **e-commerce** arena. It should not be read as a comprehensive account of the industry. To learn more about e-commerce and associated industries, please refer to content from the McKinsey Retail; Technology, Media & Telecommunications; and Growth, Marketing & Sales Practices.*

smartphone penetration rate increased from 19 percent in 2018 to 36 percent in 2022 and is expected to hit 48 percent by 2027. This growth added 400 million smartphone users in these two regions from 2018 to 2022 and could account for an additional 550 million users globally by 2027. Smartphone penetration was much higher in developed economies such as North America, reaching 86 percent in 2023. Some connectivity growth is likely to come from broadband: from 2022 to 2040, penetration in India could rise from 10 percent to 21 percent, and from 5 to 9 percent in sub-Saharan Africa.[72] These trends suggest potential for improving connectivity in developing regions.

Developed markets could see more e-commerce, too. In North America, retail e-commerce held a 25 percent share of total retail spending in 2022. The Asia–Pacific region's share was 22 percent, and Europe's was 16 percent. The lower range of scenarios estimates that retail e-commerce would increase to a 30 percent share in North America, to 28 percent in the Asia–Pacific region, and to 27 percent in Europe by 2040. The latter two markets lag behind North American penetration rates by six and eight years, respectively. In the higher range of scenarios, retail e-commerce penetration could grow to 50 percent in North America by 2040, to 40 percent in Asia–Pacific, and to 36 percent in Europe.

Most of the growth in developed markets would result from e-commerce's expansion into new categories. Consumers around the world are already accessing twice as many industries online as they did before the COVID-19 pandemic, and there are at least 25 million "high potential" customers in the United States and Europe who tried e-commerce in new categories during the pandemic but have not fully adopted it.[73] The food segment had the fastest growth from 2017 to 2022, when spending increased 34 percent a year. In some estimates, the segment's share of all e-commerce could grow from 16 percent in 2022 to about 20 percent in 2040.[74] More emotional goods such as apparel, home goods, skincare, jewelry, premium tea, and arts and crafts are also sold online through social commerce and the storytelling this approach enables (see below). In the long run, that could be a significant driver of growth for the industry, even in developed markets. The lower range of scenarios assumes limited category expansion, while the higher range assumes significant expansion.

The Asia–Pacific region has a mix of developing and developed economies with diverse e-commerce dynamics. The penetration rate of online shopping in developed economies varied. In 2023, it was 30 percent in South Korea and 15 percent in Japan.[75] It also varied in developing economies, at 36 percent in China and 32 percent in Indonesia. The rate was just 8 percent in India in 2023, but that was double the 4 percent rate in 2018, suggesting momentum.

New e-commerce formats are also driving growth. Social commerce platforms use online media to boost user and influencer interaction, promoting online sales of products and services by merging social content with shopping to enhance informed purchasing. In 2023, the top 35 leading social sellers recorded more than $24 billion (170 billion reminbi) in sales in China via live sessions across platforms. The sales from all live sessions represented more than 30 percent of total e-commerce sales in China that year.[76]

Discount and low-price platforms are also showing success. Online marketplaces such as Pinduoduo are growing fast in China through their value commerce platforms that offer affordable pricing and a game-like shopping experience. This platform model also gained popularity globally as companies such as Temu and SHEIN leveraged their strong supply chains in China, quickly scaling in the United States and Europe.

Additionally, conversational commerce, which enables sales through messaging platforms such as WhatsApp, is increasingly becoming integral to the shopping experience. The rise of generative AI (gen AI), the widespread use of chat apps, and the surge in online shopping are propelling conversational commerce, potentially boosting its market size to $41 billion by 2030. And quick commerce promises delivery to customers in hours or even minutes, a model that is particularly suited to relatively small and frequent purchases of merchandise such as convenience store items and groceries.[77]

Dynamism

In 2023, the three largest e-commerce platform providers, Amazon, Alibaba, and JD.com, accounted for 15 percent of the revenue share of all companies that sell online, including manufacturers with DTC channels, platform providers, and traditional retailers with an online channel.[78] However, the retail value of the merchandise—the total value of goods sold by merchants on the platforms, rather than the revenue of those platforms—flowing through these three platforms represented up to 42 percent of total e-commerce retail value in 2023.[79] This large share is attributable to several factors: the big investments that e-commerce companies need to make in delivery logistics, the companies' economies of scale, and the mutually reinforcing network effects of a two-sided marketplace. Customers find more value in a platform with many merchants, and vice versa.

However, emerging contenders are disrupting the status quo, rapidly scaling through innovative strategies. At least four key elements pose challenges to the incumbents, as follows:

First, DTC sales could capture a larger share of the industry's revenues. Companies such as Casper and Warby Parker sell to customers without a retail middleman. These sales are supported by third-party logistics providers such as Shopify that help smaller companies establish and maintain online retail systems (including those built into social media platforms).

Second, the growing popularity of online food purchases—the grocery segment was worth $8 trillion in annual global revenues in 2023—could open the field to emerging contenders if they can succeed in food e-commerce.[80] However, the large e-commerce incumbents are also competing in food, as Amazon did by buying Whole Foods in 2017 and offering delivery.

Third, because e-commerce could grow most quickly in emerging markets, companies that specialize in those regions could take a significant share if they enhance services for local consumers. For example, China's Tencent expanded at a 14 percent CAGR from 2018 to 2023, buoyed by the popularity in China of its social media platform WeChat, which allows users to chat, post, and purchase in one "super app." In Latin America, Mercado Libre's marketplace ecosystem recorded a 59 percent CAGR from 2018 to 2023.[81] Key features, such as an integrated payment option for Latin American countries and localized services for sellers, have helped the platform maintain its market position in a region with rapidly growing internet penetration.

Last, regulations in some markets that aim to limit the size and influence of e-commerce players could lead to more fragmentation in the industry.

Swing factors

- How might social commerce change the industry structure?
- To what degree could e-commerce develop in categories that currently are mostly nondigital, such as healthcare?
- Will adoption be faster or slower in regions with lower e-commerce penetration than in more mature markets? The pace could be influenced by factors such as regulation; by supply-side constraints, such as logistics infrastructure; or by governmental restrictions.
- How much could gen AI and other new technologies affect e-commerce? Could they kick off an escalatory race that draws new entrants? Or will technological advances be incremental and mostly used by the large incumbents to solidify their market position?
- How might innovations in physical retail influence the trajectory of e-commerce?

Contributing author:
Ben Ellencweig

2. Artificial intelligence software and services

Artificial intelligence (AI) refers to a machine's ability to perform cognitive functions that we usually associate with humans.[82] Some types of AI, such as machine learning, have been around for decades (these primarily numerical techniques used for applications such as prediction, categorization, and optimization can be described as "analytical AI"), while others are newer (although built on previous technologies). The most prominent is generative AI (gen AI), which uses unstructured inputs, most often prompts from a natural language such as English, to generate unstructured outputs. These are outputs such as text, images, audio, video, and computer code that aren't typically represented in the rows and columns of a spreadsheet or database.

We define this potential arena as services and software that incorporate AI, such as those that use natural language processing, predictive analytics, and other AI algorithms and functionalities. We excluded the hardware required to operate the technology, including components to run AI systems such as processing units and chips designed by companies such as Nvidia (which are covered in the semiconductors entry in this compendium).

The promise of gen AI became apparent in late 2022, when OpenAI released ChatGPT, a service that responds to users' questions and instructions with remarkably humanlike written answers. Since then, AI has made headlines and excited markets. Investors are flocking to companies developing advanced AI and particularly to those focusing on gen AI: equity investments in that technology jumped from $5 billion in 2022 to $36 billion in 2023. In an April 2023 McKinsey survey, nearly a third of respondents reported that their organizations were using gen AI regularly in at least one business function, and 40 percent reported that their organizations would increase their investment in AI overall because of advancements in gen AI.[83] By early 2024, ChatGPT had more web traffic than such giants as Netflix, Pinterest, and Twitch, according to a survey by FlexOS on gen AI platform usage.[84]

Predicting the future of an industry that has so recently grabbed the world's attention is difficult. Yet despite this uncertainty, there are already identified opportunities along the gen AI value chain, including building end-user applications and model hubs, and providing the tooling for machine learning or large language model (LLM) operations. There are additional opportunities for new applications of AI technologies, such as gen AI–enabled agents that act in the world, and the more expansive potential for systems whose scope of capabilities is sufficiently broad to be called artificial general intelligence.[85] In the meantime, systems tailored for specific applications are being built with customized AI models using techniques such as fine-tuning and retrieval-augmented generation.[86] And there is still plenty of headroom for the adoption of analytical AI. As companies seize these AI-enabled opportunities, the industry could become an arena. Given the rapid pace of development and breakthroughs in AI, many aspects of this field will likely undergo considerable change by 2040, with significant potential for outsize growth and dynamism over the next two decades.

*Note: This section describes the potential growth and dynamism of the **AI software and services** arena. It should not be read as a comprehensive account of the industry. To learn more about AI software and services and associated industries, please refer to content from the McKinsey Technology, Media & Telecommunications Practice and McKinsey Digital.*

Growth

Developments in analytical AI and gen AI are poised to drive the industry's growth by improving business and worker productivity. In our modeled scenarios, the arena's revenues grow from $85 billion in 2022 to $1.5 trillion in a lower range of scenarios in 2040 and to $4.6 trillion in a higher range of scenarios, a CAGR of 17 to 25 percent.[87]

Past McKinsey research analyzed more than 500 uses for AI and estimated their potential economic impact, which would have two components.[88] The first is the economic value added by analytical AI—such as machine learning and deep learning—which could amount to an estimated $9.4 trillion to $15 trillion in 2040.[89] For instance, analytical AI could revolutionize vehicle maintenance by better predicting failures, cutting operational costs in the transportation industry up to 10 percent. Or it could help clinicians detect rare diseases in patients more quickly by processing and analyzing large data sets of images.[90]

The second component is the economic value added by gen AI. About $2.6 trillion to $4.4 trillion of that annual value would come from gen AI enterprise use cases, and about three-quarters of that value would be in four areas: customer operations, marketing and sales, software engineering, and R&D. These use cases include those that reduce costs as well as those that increase revenue for individual firms, overall increasing productivity in the economy. But these enterprise use cases do not account for all the productivity gains of individual knowledge workers, automating aspects of their occupations. Incorporating all these cases of individual worker productivity enabled by gen AI in addition to the enterprise use cases could unlock a total of $6.1 trillion to $7.9 trillion of value annually.[91]

Adding these components together yields our estimated range of total economic potential of $15.5 trillion to $22.9 trillion annually by 2040. The actual amount will likely depend on two factors: how quickly AI is adopted and the technology's effectiveness. To reach the $22.9 trillion figure, the vast majority of the 500-plus use cases would have to be adopted around the world, and enterprises would have to achieve reduced costs and improved productivity. In practice, companies could most effectively implement these new technologies through transformation of business domains rather than individual use cases.[92]

To arrive at our estimates of the potential arena's revenues, we multiplied the full economic value by the 10 to 20 percent of it that technology providers typically capture. Here, if the economic impact was $15.5 trillion in 2040, and if 10 percent of that amount was captured by AI companies, the companies' revenues would come to $1.5 trillion, the amount estimated in our lower range of scenarios. If the economic impact was $22.9 trillion, and if AI companies captured 20 percent of it, their revenues would come to $4.6 trillion, the amount estimated in our higher range of scenarios.

The actual capture rate will likely depend on the industry's competitive dynamics. If a few AI software and services companies can differentiate themselves from their competitors by means of advanced technological capabilities, those companies may be able to set prices higher and produce a capture rate closer to 20 percent. If many companies are battling fiercely for business, they may have less pricing power and a lower capture rate.

Dynamism

The AI software and services industry can be described as having two segments, one nascent with the advent of gen AI, and another that is a natural evolution of the software industry. Their market dynamics and player composition may change over the next 15 years.

The first segment consists of companies that train "frontier" foundation models—that is, the biggest, most advanced models, which can perform a variety of tasks by using expansive artificial neural networks and enormous sets of varied data. (For example, the GPT models by OpenAI, Gemini by Google, Claude by Anthropic, and Command by Cohere are frontier models with language and increasingly multimodal capabilities, such as processing images.) This segment of the industry currently has a few major players because building a foundation model requires access to massive amounts of data, capital, and infrastructure. Those requirements can pose challenges even to large, established technology companies. Another factor creating barriers to entry is this segment's

dependence on the semiconductor industry, because that technology can be expensive and scarce, giving an edge to companies with access to large amounts of capital (and cutting-edge talent).

This advantage can become a virtuous cycle that keeps industry leaders ahead as a result of the difficulty a competitor might have in creating industry-leading frontier models. The first escalating barriers to entry are the high training costs and huge amount of computing power required to build frontier models. For example, Meta plans to deploy 350,000 Nvidia H100 AI chips, with a value of more than $9 billion.[93] However, some experts believe that the advent of more open-source models as well as smaller, often more customized models may lead to more fragmentation even among foundation models, potentially altering this industry segment's composition.

The industry's second segment consists of companies that produce software and services that are enabled by AI and fulfill a wide variety of specific needs in the economy. For example, companies recently funded by the start-up accelerator Y Combinator plan to use AI to serve clean-energy developers, behavioral health companies, logistics vendors, and fashion designers as clients.[94] Specialized AI software and services may be based on the frontier foundation models or on models that require less investment to train. Frameworks and techniques could be layered onto the models to build solutions that cater to specific use cases. For example, retrieval-augmented generation could be added to larger gen AI platforms to help users gather information from verified data repositories, creating a tool designed to answer specific questions accurately.[95] Also, many customers of AI software and services will require full solutions, that is, integrated offerings that include building applications, integrating software, access to foundation models (and compute power), and software maintenance and servicing.

This segment largely resembles the overall software market: it is fragmented because of the huge variety of needs and applications, and new competitors continually emerge and outcompete established ones. AI could be applied in almost all industries, vastly increasing the number of specific uses and creating significant space for new entrants. Barriers to entry would be low, and the large companies training frontier foundation models could focus on just a few of the most profitable and scalable use cases, rather than tailoring their products more narrowly for hundreds of them.

Swing factors

— Will AI continue to be constrained by the limits in the capacity of the semiconductor industry's ability to supply chips, or will another constraint such as limits on electrical power emerge as a key bottleneck in AI development and deployment?

— How will governments act to shape the burgeoning AI arena? How will they approach regulation? How might some governments invest in "sovereign AI," that is to say, an interest in having AI systems developed within their borders? How will AI regulation and capital flow differ in China, Europe, the United States, and elsewhere? How will regulations on intellectual property, safety, and the size of AI companies interact with geopolitics across different markets?

— How will the distribution of value evolve among players that train foundation models, those that provide software based on those models, and the businesses and consumers they serve, for example with the release of some open versus proprietary models? Are AI models a long-term source of value? Will they commoditize or be captured through open source?

— How will pricing models evolve? How will training costs be managed? How will the various players across the AI value chain capture value as costs and pricing models change over time?

— Is AI a supporting feature or capability of the software industry, or is it an entirely new modality of how we use technology that will transform the software industry?

Contributing author:
Bhargs Srivathsan

3. Cloud services

Cloud services providers, the largest of which are often referred to as hyperscalers, offer IT services over the internet, including on-demand IT infrastructure and platforms as a service. Cloud services have been historically divided into three segments: infrastructure as a service (IaaS), platform as a service (PaaS), and software as a service (SaaS). IaaS offers computing and storage resources over the internet, PaaS offers platform services that allow users to develop apps that can put those resources to use, and SaaS consists of software provided over the internet. In practice, IaaS and PaaS are deeply integrated, so we consider them one offering in our analysis. In addition, the types of infrastructure and platform services that cloud providers offer continues to expand, for example by encompassing capabilities enabled by artificial intelligence (AI). Our definition of the cloud services arena includes only the integrated IaaS/PaaS segment. With the growth in AI as a part of software, an increasing amount of SaaS is covered as AI software and services (also identified as a potential arena). That said, since all cloud providers are likely to see themselves as AI providers, and cloud is necessary for the computation-at-scale requirements of AI, these two arenas are inextricably linked.

By introducing new technologies, optimizing operations, and scaling, the cloud services industry can deliver services with more resiliency, enable more agility, and foster more innovation than "on-premises" infrastructure and platform solutions run by corporate IT departments. Over the past decade, more and more computing has shifted to the cloud from individual corporate systems, enterprise-owned data centers, and local networks. A survey estimates that around 94 percent of enterprises use cloud services.[96] As a result, industry revenues have grown sharply—from $32 billion in 2017 to $270 billion in 2023.

The cloud services industry is already an arena, as described in chapter 1, and is likely to remain one. In an increasingly connected world, companies will need more and more computing and storage capabilities. The Internet of Things (IoT), for instance, often requires the public cloud's ability to store, process, and analyze data on a massive scale. Companies have scaled up their cloud capabilities: over the past decade, Walmart has built a hybrid cloud platform that runs more than 1 million CPU cores and can execute 170,000 backend adjustments to the retailer's website each month, 1,700 times more than could be achieved with earlier capabilities.[97] Cloud migration at scale can also bring benefits in other industries, such as the financial and automotive sectors. For instance, autonomous vehicles are now generating and recording thousands of parameters in real time that would require the cloud to store and process and feed into R&D. AI also needs this computing ability, and smaller providers focusing on the AI market have recently entered the cloud services industry.

As the cloud opens up the potential to reallocate where computing gets done, some specific workloads could be intentionally deployed "at the edge," that is, on local computing systems. These include applications with low latency requirements (including real-time applications such as autonomous vehicles or manufacturing) or where security/privacy concerns could be mitigated by constraining data to specific devices. And many workloads will be spread across cloud and edge, resulting in hybrid solutions.

The rate of cloud migration may be slower than some expected due to large time and investment needs—companies with cloud programs profiled by McKinsey increased their cloud adoption by only 5 to 10 percent between 2022 and 2023.[98] However, migration of workloads to the cloud is also expected to continue. By 2030, cloud services could generate $3 trillion of EBITDA increases for Forbes Global 2000 companies by helping them digitize core operations, accelerate product development, and more.[99] This means value remains on the table: cloud players still have opportunities to harness returns on investments on cloud at scale.

*Note: This section describes the potential growth and dynamism of the **cloud** arena. It should not be read as a comprehensive account of the industry. To learn more about cloud and associated industries, please refer to content from the McKinsey Technology, Media & Telecommunications Practice and McKinsey Digital.*

Growth

We anticipate that cloud adoption could grow further as a result of continued enterprise migration to cloud services and increased demand for cloud services to meet the computational needs of new technologies. We excluded SaaS in our estimates because it occupies a separate competitive space from cloud infrastructure/platforms; pure software companies and infrastructure-and-platform providers operate differently, compete in different markets, and have different financial models.

Global external IT spending was about $3 trillion in 2022 and is expected to grow to $8 trillion in 2040, a 6 percent CAGR. These outlays are distributed across key areas, such as hosting, network, cybersecurity, and application development and support. Our estimates include spending on public cloud service providers and exclude internal labor cost. The cloud services industry's 2022 revenues accounted for 8 percent of global IT external spending. In our estimates, the industry could represent between 19 and 41 percent of that spending by 2040. In our analysis of today's cloud arena, the industry's revenues grew at 17 percent CAGR from 2005 to 2020. They could continue to increase at a similar rate, or growth could be slightly moderated to a 12 percent CAGR. Revenues could increase from $220 billion to $1.6 trillion in the lower range of scenarios and to $3.4 trillion in the higher range of scenarios in 2040.[100]

Our scenarios are based on two factors: first, companies continue to migrate their traditional computing and storage processes to the cloud.[101] Despite the strong growth of cloud services over the past decade, a 2023 survey of enterprises with more than $1 billion in revenues found that only about 20 percent of their workload was in the cloud, and most planned to more than double that share by 2026.[102]

This continued migration would increase the share of cloud expenditures in overall hosting and networking IT spending. In addition, the cloud could capture a larger share of cybersecurity outlays, as certain on-premises cybersecurity software services migrate to the cloud.

In the higher range of scenarios, migration happens quickly, and the cloud industry captures more spending from hosting, networking, and cybersecurity. In the lower range of scenarios, migration is slower and, in some cases, reverses for certain workloads (such as cloud "repatriation," the process of moving applications from the public cloud to private infrastructure). Slower cloud migration and increased repatriation could have several causes, including malfunctions or breaches at cloud providers, data protection laws, and security and privacy concerns (for example, national security concerns for defense-related industries).

The second factor underpinning our estimates is the computational requirements of newer technologies—such as AI, IoT, and virtual reality—that could boost demand for cloud services. The need for computational power of generative AI (gen AI) models is particularly high during the training phase, which typically involves computationally intensive operations, but the volume demand for inferencing (the use of these models) could also rise as AI adoption increases (though some inferencing could also be deployed at the edge). Many in the AI industry have highlighted insufficient computing power and limited availability of graphics processing units (GPUs) as the key bottlenecks in the development of the technology. Nvidia, a leading player in the AI technology market, has announced plans to meet this growing need by shipping 1.5 million AI server units that will consume 85 terawatt-hours (TWh) of electricity a year by 2027,[103] representing 25 to 35 percent of the 240–340 TWh of energy that cloud data centers used globally in 2022 (see the entry for semiconductors in this compendium).[104] The rapid growth in AI services may continue to drive significant demand toward cloud services. In the higher range of scenarios, AI technologies grow more quickly and businesses require large amounts of cloud service to enable that growth. In the lower range of scenarios, businesses do not employ these technologies as widely, so the need for additional cloud services is limited.

Dynamism

The cloud services industry has few major players; its four largest companies currently account for about 60 percent of total revenues. In 2023, Amazon Web Services (AWS) took in 31 percent, Microsoft 20 percent, Google 7 percent, and Alibaba 3 percent.[105] These companies have grown thanks to significant network effects, scale and scope advantages, and high barriers to entry. To be competitive, providers must make very large investments, particularly in data centers: the three companies with the highest capital expenditures from 2016 to 2021 (AWS, Microsoft, and Google) invested more than $380 billion over a five-year period, nearly 60 percent of the industry's total. With companies migrating more of their workloads to the cloud, competition may intensify as cost and convenience become more important to customers. Achieving competitive pricing and migration experiences also requires large amounts of R&D.

In the long term, the industry may continue to have just a few large players given its escalatory dynamics and global radius of competition. Large companies are already investing heavily in acquisitions to help them offer more specialized services.

However, data sovereignty regulations[106] and new investments in different regions of the world could cause some fragmentation by enabling the emergence of regional competitors. Yet even in that scenario, investment and economics of scale would probably leave room for only a few surviving competitors in each region. In addition, the global presence of major hyperscalers will likely allow them to adjust to data sovereignty rules and continue to compete in regional markets.

Cloud services tailored for AI—a rapidly growing segment within the larger cloud-services industry—could lead to shifts in market share among companies. Such services give clients the tools and infrastructure they need to develop, train, and deploy AI and machine learning models at scale. A few new players have cropped up; for example, specialized GPU cloud providers have grown quickly due to their data centers and services tailored to meet the unique needs of AI model training and deployment. The largest companies in the cloud services industry, including Microsoft and Google, also offer "frontier" foundation AI models, which clients can use to create more specialized models. It is easy to imagine that the fierce competition for performance among frontier models could shift share among cloud providers.

Swing factors

- How costly and challenging will cloud migration be?
- Will the massive volumes of data in legacy systems make it less cost-effective for enterprises to transfer workloads to the cloud?
- Could there be regulatory concerns particularly about concentration risk? Could this drive companies to use private infrastructure rather than the public cloud?
- How will increasing data residency regulations and sovereign AI impact the adoption of public cloud for enterprise workloads?
- How could gen AI adoption accelerate cloud adoption, and how would it shift corporate budget allocations among IT, product, R&D, and other areas? For instance, could generative AI make it cheaper to build applications? Will AI workload demand surge as anticipated, or can businesses optimize training processes that will reduce this demand in the cloud?
- If a catastrophic failure or cybersecurity attack occurred at a major provider, what potential scenarios could unfold?

Contributing authors:
Moritz Rittstieg,
Patrick Schaufuss

4. Electric vehicles

The technology to build electric vehicles (EVs) has existed since the invention of the automobile in the 19th century, and electric cars vied with steam-powered and gas-powered vehicles well into the 20th century. The introduction of the Ford Model T, the proliferation of cheap gasoline, and the use of internal combustion engine (ICE) vehicles during World War I eventually led to mass-market adoption of the gas-powered vehicle.

More recently, however, EVs have been mounting a global comeback as concerns about CO_2 emissions from traditional ICE vehicles made them an attractive alternative. With recent investments in technology, they have become increasingly practical and mainstream—in 2023, EVs accounted for 18 percent of all new passenger cars sold globally. Between 2010 and 2019, breakthroughs in battery capacity and efficiency increased the range of the average battery electric vehicle (BEV) from 130 kilometers to 340 kilometers. In the same period, the launch of lower-cost EV models brought down the average purchase price from $55,000 to $37,000, a decrease that put the total cost of ownership of many EVs over their lifetime roughly on a par with that of a comparable ICE car.[107]

At the same time, EVs are getting a boost from mandates and timelines in several countries seeking to eliminate the use of ICE vehicles. That includes a law approved by the European Union in 2023 that effectively banned the sale of many new ICE vehicles by 2035, and mandates in Canada and the state of New York requiring that 100 percent of new passenger vehicle sales be electric in the next 10 to 15 years.[108]

As a result, the EV industry became one of today's arenas, as described in chapter 1. Plenty of signs indicate that it could be one of tomorrow's, too. EVs are growing significantly faster than the rest of the automotive sector. Overall annual passenger vehicle sales are projected to increase at a modest rate, from 74 million in 2023 to 79 million in 2030. By contrast, global passenger EV sales are projected to increase fourfold, from 13 million in 2023 to between 31 million and 46 million in 2030, or about half of the total annual sales of all cars forecast for that year.

Escalatory competition has been ramping up in the global EV market. Chinese EV companies have begun exporting to global markets, with OEM BYD overtaking Tesla in global EV sales in the fourth quarter of 2023 and Chinese brands accounting for about 50 percent of global BEV sales. Other OEMs are looking to compete. BMW reached one million cumulative EVs delivered in the first quarter of 2024, with sales up more than 25 percent year-on-year.[109] Ford's electric vehicle sales were up 85 percent year-on-year in the first quarter of 2024, even as the company has delayed production of new electric pickups and SUVs.[110]

However, the market has seen some slowdowns, such as delayed electrification targets of some OEMs, and in 2024 experts revised EV sales growth projections downward for the first time. There are concerns that early adopters have already purchased their first electric vehicles, and the next wave of potential adopters may have stronger concerns about price and range that would slow growth. But even with these recent headwinds, EVs are still experiencing strong growth, though it is less accelerated than in the vehicles' early years. R&D investment in EVs remains a priority, and EV-focused companies continue to spend more than traditional carmakers. In 2023, Tesla spent $4 billion on R&D, or about $2,200 per car, 1.2 times more than what Ford spent, and almost 3.0 times Toyota's spending.

*Note: This section describes the potential growth and dynamism of the **electric vehicles** arena. It should not be read as a comprehensive account of the industry. To learn more about electric vehicles and associated industries, please refer to content from the McKinsey Center for Future Mobility.*

Growth

The growth of EVs responds to the continued prioritization of sustainability by consumers and governments, lower lifetime costs of ownership, escalatory competition to improve quality, and enabling investments in charging infrastructure and electricity supply and distribution. Our estimate of electric vehicles' growth includes revenues attributable to producers of BEVs, plug-in hybrid electric vehicles, and fuel-cell electric vehicles (FCEVs), which run on hydrogen. We include both passenger vehicles and commercial vehicles such as trucks and vans.[111] We exclude hybrid vehicles that don't have the ability to be plugged in to recharge, as well as vehicles powered by natural gas.

To obtain our estimate of revenues for the entire EV industry, we included the sales of electric passenger vehicles and commercial vehicles, including heavy-, medium-, and light-duty trucks, as well as light commercial vehicles. In our estimates, revenues would grow from $450 billion in 2022 to $2.5 trillion in the lower range of scenarios and to $3.2 trillion in the higher range of scenarios by 2040, implying a CAGR of 10 to 12 percent. In 2023, revenues were $590 billion.

In 2023, 18 percent of all new passenger vehicles sold globally were EVs. However, the sales numbers vary by region: in China, almost 30 percent of new passenger vehicles were EVs; in Germany, 30 percent; in France, 20 percent; in the European Union, 16 percent; and in the United States, 8 percent. In July 2024, more than half of the vehicles sold in China were "new energy vehicles," including BEVs and plug-in hybrids.[112] In our estimates, the global share increases to between 82 and 96 percent by 2040. Projections also vary greatly by region. In high-penetration regions like Norway, the EV share of passenger car sales could grow from about 90 percent currently to 100 percent, while lower-penetration countries such as Nigeria could see that share growing to only 15 to 22 percent by 2040. As a result, industry revenues from passenger EVs could grow from $530 billion in 2023 to between $2.0 trillion and $2.3 trillion in 2040, implying a CAGR of 8 to 9 percent. In 2023, revenues were $530 billion. With EV sales estimated to overtake ICE sales sometime between 2025 and 2030, most of this growth would come from replacing traditional ICE sales, whose share would decline by a corresponding amount (Exhibit 1).

Electric vehicles could account for about half of global passenger vehicles sales by 2040.

Exhibit 1

Sales of electric passenger vehicles may surpass sales of internal combustion engine passenger vehicles by 2030.

Note: Projections show middle scenario. Passenger vehicle totals exclude commercial vehicles, such as light commercial vehicles, light-duty trucks, medium-duty trucks, and heavy-duty trucks. Electric category includes battery electric vehicles, plug-in hybrid electric vehicles, and fuel-cell electric vehicles.
Source: McKinsey Center for Future Mobility (May 2024)

McKinsey & Company

Among commercial vehicles, by contrast, the share of BEVs and FCEVs sold was only about 4 percent in 2023 (Exhibit 2). In our estimates for 2040, that share would grow for medium- and heavy-duty trucks to between 60 and almost 90 percent in regions of high penetration, such as Europe, where regulations aid EV adoption. In regions with medium penetration, such as the United States and China, the estimated share is 40 to 80 percent. In the rest of the world, that share could grow to between 10 and 50 percent. To reach these shares, however, battery electric trucks could require either significant improvement in battery energy density or reduced payloads compared with traditional diesel trucks, which could challenge the economics of the trucking industry. An alternative to BEVs would be a higher share of FCEV trucks, which do not face the same range and payload trade-offs but would need a major scale-up of hydrogen refueling stations and development of a robust hydrogen supply chain. Because of this trade-off, some medium- and heavy-duty trucking use cases such as long-haul freight could be suited to FCEV power trains. However, heavy-duty trucks in use cases with more predictable downtimes and distances driven per day, such as those used for garbage, sanitation, or local distribution, are more likely to use BEV power trains.

Exhibit 2

Sales of electric commercial vehicles may surpass sales of internal combustion engine commercial vehicles by 2030.

Note: Projections show middle scenario. Commercial vehicles include light commercial vehicles, such as light-duty trucks, medium-duty trucks, and heavy-duty trucks. Electric category includes battery electric vehicles, plug-in hybrid electric vehicles, and fuel-cell electric vehicles.
Source: McKinsey Center for Future Mobility (May 2024)

McKinsey & Company

By contrast, light-duty trucks and light commercial vehicles are likely to be primarily BEVs. This is because these smaller trucks and commercial vehicles are much lighter and so will not face as stark of a range and payload trade-off as heavier trucks. For example, Tesla's Cybertruck weighs roughly 3,000 kilograms (kg); the battery alone for a heavy-duty garbage truck can weigh more than 7,000 kg. EVs' share of vehicle sales for these lighter segments is estimated to be 85 to almost 100 percent in regions of high penetration such as Europe and China; between 50 and almost 100 percent in the United States, which has medium penetration; and between 30 and 80 percent in the rest of the world.

Taken together, revenues from EV light commercial vehicles and light-, medium-, and heavy-duty trucks combined would grow from $42 billion in 2022 to between $540 billion and $900 billion in 2040, implying a CAGR of 15 to 19 percent. In 2023, revenues were $53 billion.

Four main factors are driving growth to the higher or lower end of that range: consumers' willingness to pay a premium for sustainable vehicles, EV cost and quality, charging infrastructure, and the supply and distribution of electricity to the charging infrastructure.

Willingness to pay a purchase premium for sustainable vehicles and policy incentives. The global effort to mitigate climate change and reduce carbon emissions is driving governments and consumers toward lower-emissions options. In 2023, ground transportation globally accounted for roughly seven gigatons of CO_2 emissions, or about 20 percent of global emissions, making it a priority sector for emissions reduction.[113] These considerations help power consumer demand, with 57 percent of all global car buyers in the McKinsey Center for Future Mobility (MCFM) consumer sentiment survey for 2024[114] stating that sustainability was a primary factor when purchasing a new

car, though this varies hugely across regions. In the United States, only 49 percent said sustainability was a primary factor. In China, the figure was 59 percent, while in Germany it was 43 percent.

These concerns also drive policy. Governments around the world are offering incentives for EV purchases, and the EU and 12 US states have instituted bans on new ICE vehicle sales that will take effect in 2035.[115] In the United States, buyers of many new EVs receive a tax credit of up to $7,500, and buyers of heavy commercial EVs could receive a tax break of up to $40,000 per truck under the 2022 Inflation Reduction Act (IRA).[116] Chinese EV buyers receive tax exemptions worth $2,000 to $4,000 on EV purchases, and in major Chinese cities, EVs receive preferential vehicle registration that can save car purchasers meaningful money or time. The strength of continued consumer demand and political pressure for lower carbon emissions will determine whether this factor drives growth toward the higher or lower end of our estimates.

EV cost and quality. Several technological factors drive EVs' cost and quality, and they could determine whether revenues tend toward the lower or higher end of our range. By 2023, most EVs had reached parity with comparable ICE vehicles on total cost of ownership over the vehicle's lifetime, though this depends on the region, car make and model, usage profile, and available subsidies. However, this parity has limited impact on consumers, who are largely more sensitive to purchase price than to a complicated calculation of the total cost of vehicle ownership over many years. And EVs remain meaningfully more expensive to purchase than comparable ICE vehicles.

The battery is a main driver of EV cost and accounts for 30 to 40 percent of the total cost of a vehicle. Several forces affect battery prices, with more than half the cost of a lithium-ion battery coming from its raw materials. Prices of lithium, a critical raw material, have been volatile, increasing about fivefold from January 2021 to January 2023 before falling back to 2021 levels by January 2024. Supply dynamics could also affect battery prices. Even though identified global lithium reserves are four times larger than the amount that would be needed to supply batteries for projected EV sales between 2022 and 2040, meeting EV demand could still require a three- to fivefold surge in lithium production.

The rapid proliferation of EVs is also likely to add to the demand for other key materials such as cobalt and nickel. Yet EV battery pack prices have fallen significantly over the past decade, thanks to technological improvements and economies of scale, which caused costs to plummet from thousands of dollars per kWh in the early 2000s to under $100 per kWh today. McKinsey's Battery Insights team forecasts that the cost could to continue to decline to $50 to $75 per kWh by 2040, mostly driven by continued technological improvements in energy density. While the price of the raw material inputs is volatile and harder to predict, designers have managed to adapt the mix of materials in batteries (for example, by reducing the amount of cobalt used) and may be able to keep doing so (for example, by using cheap, abundant sulfur). In addition, batteries can be recycled to reclaim the raw materials within them, as some companies are already doing and some regulations already require. If those trends continue, they could help keep down future prices in the event that the price of raw materials spikes.

Battery lifespan can be another concern for EV buyers. Recent research has suggested that batteries tend to last for the lifetime of a typical vehicle, about eight to 12 years, depending on how far they are driven. A 2024 survey of 20,000 EV drivers found that less than 1 percent of cars manufactured since 2016 required battery replacement, compared with 13 percent for cars made in 2015 or before.[117] Most EVs do not use a full battery cycle—charging to 100 percent and depleting to zero percent—but instead charge to about 80 percent and avoid falling lower than 20 percent, which can significantly improve battery lifespan. And fast-charging a vehicle doesn't seem to make a meaningful difference in battery lifespan, as long as the fast charge does not fully cycle the battery. See further discussion in our "Batteries" entry in this compendium. Range also influences EVs' rate of growth. About 70 percent of consumers in a February 2024 survey by MCFM agreed or strongly

agreed with the statement, "I am anxious about buying an electric vehicle because of the limited driving range." This "range anxiety"—the worry that a single charge might not allow an EV to go as far as an ICE car—is their biggest concern about owning an electric vehicle, and about 30 percent of those surveyed said insufficient range is their primary reason for not purchasing an EV. According to a previous MGI analysis,[118] however, passenger BEVs are already able to meet most use cases in driving range. In the United States, the median range of a BEV is about 400 kilometers, which would be sufficient for about 80 to 90 percent of journeys made without having to recharge by average US households. The average driver in the United States drives close to twice as far each year as drivers in Australia, France, and the United Kingdom, implying that the share of use cases currently met by BEVs would be even higher. Thus, the rapidity with which EV car design, battery technology, and electric power trains improve will determine whether some consumers will be able to overcome range anxiety and purchase a vehicle.

Charging infrastructure. The sheer scale of the infrastructure needs for EV charging introduces factors that could limit the industry's growth. While the infrastructure to distribute and sell gasoline around the world was built up over decades, the public and private chargers for millions of EVs would have to be built at scale in less than a decade to meet growing EV demand and to achieve climate goals. Although public charging infrastructure grew at a rapid rate of about 50 percent annually from 2018 to 2023, this growth was heavily driven by China, which accounts for about 70 percent of global public charging points. Other regions have struggled to keep pace with the growth of EV sales: there are eight EVs per public charging point in China, 14 in Europe, and 30 in the United States. Charging infrastructure would need to be built in homes, offices, shopping centers, and along highways, to name just a few locations. We estimate that 135 million charging points may be needed globally by 2030 to meet EVs' energy demand, nearly five times the 25 million charging points installed by 2023, including about 15 million public chargers.

This infrastructure requires substantial investments. About $2 trillion in global capital expenditures may be needed until 2050 to build the public and private charging infrastructure required to meet EV demand.[119] While EV charging infrastructure (EVCI) is likely to become a meaningful industry in its own right, whether it can scale up sufficiently to support growing EV adoption is unclear. Profitability for public EVCI operators is highly dependent on the utilization rate, which is a function of how many EV drivers are nearby, and EV demand is capped by consumer concerns about the availability of public charging. Timing will be critical: scaling up too slowly would limit consumer EV demand; scaling up too rapidly could mean large losses while EV adoption catches up. Many public-charging operators are operating at a loss, investing in a network in hopes that it delivers future profits. Some legislative efforts (such as the US IRA) have aimed to encourage EVCI network building, but it remains to be seen whether those measures will spur enough EVCI investment fast enough to allay concerns about charging availability.

Electricity supply. The EV industry could also be limited by the supply and distribution of electricity to the charging infrastructure. To power the more than 240 million EVs on the road just by 2030, we estimate annual electricity needs would grow from around 140 million megawatt-hours (MWh) in 2022 to more than one trillion MWh by 2030, representing about 3 percent of future global electricity generation.[120] This electricity would also need improved transmission and distribution infrastructure: many of the 26.5 million chargers projected to be built in private settings (such as those in homes, offices, and retail locations) may need the local utility to install improved substations that can handle a larger load than the current infrastructure. Timing is important as well. Many EVs are charged at night, so there will be a need for better energy storage solutions as well as renewable power generation at night (for example, excluding solar).

And to deliver on its promise of reducing greenhouse gas emissions, the electricity powering EVs would need to come from low-emissions sources. Because the manufacturing process for EVs

emits more carbon than the making of an ICE car does, it can take 30,000 to 80,000 kilometers of driving for passenger cars and 35,000 to 65,000 kilometers for heavier sport utility vehicles to break even on their lifetime carbon emissions on grids such as those in Europe and the United States. Typical vehicles in the United States and Europe are driven distances of about 150,000 to 250,000 kilometers, so BEVs may produce emissions that are 20 to 60 percent lower than top-performing ICE vehicles in their lifetimes. For heavier vehicles and in areas where the grid is more carbon intensive, that break-even point gets further away (a heavy SUV on a carbon-intensive grid such as India's may not reach carbon breakeven during its expected lifetime). If EVs fail to deliver on their promise to reduce carbon emissions, consumers and governments may not continue to support their growth.

Dynamism

The EV market, which currently features a few large players, has seen increased numbers of Chinese players and EV-focused new entrants alongside traditional manufacturers that have existing competencies in manufacturing and are competing at scale. In the early 2010s, Chevrolet and Nissan started selling plug-in electric cars, followed closely by Tesla. These manufacturers were able to gain large market shares in the early years because there were fewer players and limited models were offered. They could move quickly and scale up in EVs before other carmakers entered the market. Notably, Tesla successfully scaled up Model 3 production, gaining up to 40 percent share of the US market in 2018.[121]

Fast-forward to today, and the market still has just a few large players. In 2023, the five largest EV producers, led by BYD, controlled about 50 percent of total EV production, while the top five players accounted for only 35 percent of the overall passenger car market, still led by ICE vehicles.[122] Nonetheless, there have been many new entrants into the EV market, both start-ups, such as Polestar and Lucid, and major automotive OEMs, such as Ford and Hyundai. And in China, an entirely new ecosystem has developed around EVs, with vertically integrated players such as BYD. The rapidly expanding Chinese domestic market for EVs features just a few larger players, with the five biggest Chinese companies combined selling 60 percent of all EV units sold in 2023.[123]

Chinese companies such as BYD and Geely have also increased their EV sales massively outside of China: in 2023, they produced about 50 percent of EV units sold globally. In Brazil, four of the top five EV sellers were Chinese companies, selling a combined 80 percent of EV units in the country.

New entrants have found fertile ground in EVs: in 2023, about 50 percent of new EV units were produced by companies that sold more EVs than ICE vehicles. Part of the reason new entrants are finding success in the market is that the embedded capital and skills of the traditional ICE incumbents—such as their expertise in building ICE power trains and managing an extremely complex network of suppliers—did not confer a strong enough advantage to these incumbents to prevent new entrants from successfully entering the market. This is an example of the escalatory dynamic we explore in chapter 2, in which a technological step change can open up the bottom of a new S-curve, enabling the entry of disruptive new players.

However, OEMs that sell more ICE vehicles than EVs still occupy a major role in the industry and are increasingly investing in EVs. However, the dynamics are different in different markets. In Norway, OEMs that sell more EVs than ICE vehicles sell about half of EVs, whereas in Brazil, new EV entrants have a roughly 70 percent market share, with BYD leading at more than 36 percent of EV sales.[124]

The game could play out in many ways. The older automakers have some advantages, including, above all, the expertise necessary to manufacture products at large scale. But EV-only companies also have an advantage: a laser focus on EV power trains. EV-only companies can streamline their research, design, and manufacturing operations to focus solely on electric vehicles, while traditional

automotive OEMs must continue to optimize across a wider portfolio of EVs and ICE cars, and may not be able to optimize for EV production in the same way. In addition, expensive battery packs are the heart of every EV, and the R&D invested in enhancing battery performance could prove even more valuable than the ability to build the rest of the car. EV-only companies could successfully entrench themselves in the market by capitalizing on first-mover advantages, scaling up and bringing down prices, and offering customers higher quality, such as better range. And players in either group may continue to integrate vertically, as BYD has done with battery production and even battery raw material mining; the carmaker is involved in lithium mining from China to Chile.

Swing factors

— Will more consumers be won over to EVs as electric vehicles get better and the infrastructure expands, or are there deeper consumer preferences toward ICE cars beyond just solving for cost and convenience?

— Will the industry be successful in ramping up mining to meet raw material demand at the right speed to match the growing demand in EV batteries? If not, how will the swings in price and availability along the EV supply chain change the trajectory of the industry?

— How will the pace of the energy transition, including government support for it, affect the EV market? Depending on the development of the market, will bans on ICE vehicle sales remain in place or be reconsidered?

— Will the buildup of public charging infrastructure be sufficient to meet EV demand?

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Contributing authors:
Craig Macdonald,
Lia Grigg

5. Digital advertising

Digital advertising funds an enormous swath of the internet by providing an increasing percentage of its revenues.[125] Growth in digital ads is expected to continue, indicating that the industry could be one of the arenas of tomorrow.[126]

There are several reasons to believe digital ads will continue to expand their reach. First, more people around the globe are coming online and joining the global middle class, resulting in more consumers for companies to target with digital advertising. Second, consumers are spending more time with media, and increasingly in digital forms, resulting in both an increased volume of novel ad products and more demand from advertisers. Third, the digital shift is creating more innovation in, and better performance from, ad products. The digital shift also lowers costs for advertisers to enter the market (for example, generative AI, known as gen AI, reduces the cost of content creation). This generates more demand and expands the total addressable market. Last, more places to display advertising are emerging, and ads are becoming a more important revenue model for non-traditional advertising sectors such as e-commerce, retail, last-mile delivery, banking, and telecom, especially in developing economies.

Digital ads could also see high dynamism. Several factors contribute to this: the evolution of walled gardens (closed platforms where providers have full control over content and consumer data), the impact of gen AI on traditional search and on small and midsize business (SMB) access, regulatory and data privacy actions, the rise of social media influencers, the convergence of commerce and advertising, and shifting consumer behavior.

*Note: This section describes the potential growth and dynamism of the **digital advertising** arena. It should not be read as a comprehensive account of the industry. To learn more about digital advertising and associated industries, please refer to content from the McKinsey Technology, Media & Telecommunications Practice and Growth, Marketing & Sales Practice.*

Growth

Digital advertising is expected to continue to grow faster than GDP. In our estimates, revenues from digital advertisements increase from $520 billion in 2022 to $2.1 trillion in the lower range of scenarios and to $2.9 trillion in 2040 in the higher range of scenarios, a CAGR of 8 to 10 percent.[127] Much of this growth comes from the ongoing shift in advertising spend from traditional to digital media: in 2022, digital advertisements accounted for 65 percent of total advertising, a share that is expected to grow to 80 to 90 percent by 2040 (Exhibit 1).

Exhibit 1

A mix of shifting market share and overall market expansion could power growth in digital ads.

Spending on advertising, $ billion

Note: Figures may not sum to 100%, because of rounding.
[1]Traditional ads are those displayed on non-digital channels such as TV, radio, and print media.
[2]Digital ads are those consumers see on computers and mobile phones.
Source: McKinsey analysis incorporating data from EMARKETER, Statista, Oxford Economics, PwC Global Entertainment & Media Outlook 2023–2027: Moffett Nathanson, and Magna

McKinsey & Company

The growth of digital ads is primarily driven by four factors: growth of the global middle class, consumer attention moving to digital, the demonstrated ROI of digital ads, and new forms of digital media.

First, digital advertising may grow as more of the world comes online and more of the global population enters the middle class. This could increase the number of people that companies around the world are trying to reach and enable digital ways to reach them. In particular, developing economies and regions could see substantial increases in smartphone and broadband penetration bringing more consumers onto the platforms that serve digital ads and improving the effectiveness (and pricing) of those ads with more user scale and richer and broader data signals. For instance, the Asia–Pacific region, Latin America, and the Middle East and Africa could achieve a smartphone penetration level of almost 90 percent as soon as 2026 (Exhibit 2). In addition, the ten countries with the largest projected increase in middle-class population from 2020 to 2030 are all developing economies. Collectively, these ten countries could have about 900 million people making the transition into the middle class in this period.[128]

Exhibit 2

The world—especially emerging markets—will be increasingly online.

*Projected
Source: Analysys Mason

McKinsey & Company

Second, consumer attention will continue to shift to media, and increasingly to digital formats. Overall time spent on media has mostly been increasing across economies, but more notably in developing economies. For example, Indian consumers spent 225 minutes per day on average on media in 2016, and this could increase to almost 400 minutes by 2026, or a 6 percent CAGR, while Chinese consumers' time spent on media could climb from 384 minutes per day in 2016 to almost 500 minutes by 2026, a 3 percent CAGR. The share of digital media—where consumers are served digital advertising—in particular is increasing across economies. In the United States, digital media accounted for 40 percent of consumers' media consumption in 2016. That could grow to 66 percent by 2026 (Exhibit 3).

Exhibit 3

People are spending more time consuming digital media.

Distribution of time per day spent on different media channels, %

*Projected
Source: EMARKETER; McKinsey Global Institute analysis

McKinsey & Company

Third, digital ads continue to demonstrate improving ROI. Digital ads offer advertisers more measurable formats, such as search and "performance" advertising, in which companies pay for clicks and measurable results instead of promoting general brand awareness. These formats also offer the ability to deliver ads to very specific and precise target audience segments, allowing advertisers to more efficiently deploy their advertising budgets and measure much more precisely their effectiveness.

The ability to execute targeted and highly measurable campaigns has enabled SMBs, which could not afford and did not benefit from broad-audience brand advertising on traditional media, to become a significant force in advertising. It is also increasing the overall number of advertisers substantially: in 2020, 200 advertisers supplied 88 percent of US TV ad revenue, while three million advertisers were on Facebook,[129] the vast majority of which were SMBs. These SMBs will continue to expand the market as the shift to online video and connected TV opens up new digital advertising formats to smaller advertisers who would never advertise on traditional TV.

New technologies such as gen AI are expected to make digital ads more effective by enabling hyper-personalization of content and could increase demand for digital ads by making digital ads cheaper and easier to produce. For example, the online used-car marketplace Carvana used gen AI to create 1.3 million bespoke videos aimed at individual customers. Each ad celebrated a customer's car purchase in a personalized way.[130] Virgin Voyages created a tool that uses the digital likeness of entertainer Jennifer Lopez (the company called the tool "Jen AI") and allows customers to share personalized video invitations with friends.[131]

Fourth, new forms of digital media, such as retail media, video games, and digital out-of-home, are emerging. Many of these forms did not exist or had little scale a decade ago but are growing rapidly today. Innovative formats enable new players outside of traditional and digital media to sell ads, further increasing the supply of ads. Companies including Amazon, Chase, United, and Uber have added ads to their digital platforms. Video game platforms such as Roblox have increasingly used digital ads to boost revenues; digital advertising almost doubled as a proportion of global mobile gaming revenues, from 28 percent in 2017 to 51 percent in 2022.[132]

Advertising has also become an increasingly important revenue model for media companies. This is especially true in developing countries where consumer willingness to pay for media is low, contributing to the growth of advertising-enabled media models. For instance, around 60 percent of the 135 million monthly active Spotify users in Latin America, one of the fastest-growing regions, are on the free, ad-supported version of the application.[133] In developed markets such as the United States, ad-supported tiers of the leading streaming platforms are emerging as both higher revenue and higher margin than subscription-only tiers. For example, in 2023 the ad-supported tiers of Discovery, Hulu, Netflix, and Peacock each had higher average revenue per user than their premium subscription tier.[134]

Dynamism

The industry benefits players with scale due to two-sided network effects of both users and advertisers: a larger pool of users and data enables better matching and signaling, giving advertisers incentive to continue placing advertisements on these platforms as performance improves. As of 2023, four companies accounted for about 64 percent of the industry's global revenues—Alphabet, with 30 percent, Meta, with 21 percent, Amazon, with 7 percent , and ByteDance, with 6 percent.[135]

The industry's total addressable market may continue grow, but shifts in market shares remain uncertain. While large incumbents may still see growth, two questions are relevant in understanding how the industry's structure may change: First, will the value from newly emerging revenue pools be captured by new entrants or by incumbents? Second, to what degree is the core business of

incumbents at risk of capture by new entrants? In a more disruptive scenario, new entrants may emerge and evolve into a new set of large players if outsize shifts occur.

Several major dynamics will likely determine how these share shifts play out in the next 15 years, across both the supply side, meaning the extent of advertising players can provide, and the demand side, or the channels where consumers will interact with ads and the number of advertisers and the share of revenue they spend on digital advertising.

From the supply side, several factors could change the industry's structure, potentially shifting shares of current players. First is the degree to which walled gardens stay global. As new mixes of content and user data are emerging, the competitive position of existing walled gardens may be challenged. Because SMBs may drive regional growth, a new wave of walled gardens whose sizes and scopes would be more regional than global could emerge.

Second are new formats. New form factors, such as virtual conversational agents that help consumers discover products, may provide new marketing experiences for consumers. The extent to which players succeed at creating innovative formats could drive large share shifts even among the existing players, and open up space for new entrants, though those new entrants would need to invest heavily in technologies such as AI in order to compete. The rise of influencers is an example of how an emerging format shifted shares in the industry; advertisers have reallocated spend to influencers and away from traditional paid media to reach more consumers.

Third is the convergence of commerce and advertising. The extent by which closed loops win out and how much commerce players move to invest in content could structurally change the industry. Commerce players have large amounts of consumer data, which they could leverage when expanding into advertising on their channels.

Fourth are regulatory and data privacy actions. Developments in local or regional policies, such as laws related to data collection, management, and residency, could have significant operational requirements for advertising companies that aspire to participate globally. These policies include the General Data Protection Regulation in Europe and the American Data Privacy and Protection Act, which is the subject of ongoing discussions.

From the demand side, the shifts in consumer behavior could change how and where advertisers can find consumers. For instance, channels in which consumers discover various products or services, and the ways consumers engage with brands such as through connected TV and app stores, can influence where consumer attention—and hence revenue—shifts. Consumer preferences could also move toward user-generated content and short-form videos such as those on TikTok. Ad expenditures follow consumer attention and spending; if new platforms attract more consumer attention, the relative ad spend on those platforms will also increase due to the supply factor of new advertising formats explained above.

The impact of gen AI has crosscutting effects on both supply and demand, affecting how advertisers can participate as well as changing customer behaviors. For one, gen AI could transform how consumers navigate media and the internet. For example, it could disintermediate traditional search and allow customers to discover information or products directly, thereby creating a new channel for ad placements. Gen AI also democratizes content creation by making it cheaper and easier for SMBs, which can now advertise in more formats.

Swing factors

- As new walled gardens emerge, how will the interoperability between platforms evolve, and how will ad delivery enablers including "open ad tech"—the ecosystems on the open web that connect advertisers and publishers—and ad agencies respond?
- How will gen AI affect the customer journey, from brand to product and from discovery to purchase, including potentially disintermediating search? How will it affect the degree of consolidation or democratization of digital content?
- Which emerging media formats—for example, augmented reality and virtual reality, metaverse, and wearables—will create new channels of customer attention, and how will advertisers adapt to deliver ads using these new formats?
- How will brand advertising change as performance advertising becomes increasingly common, and where will brand advertising spend be directed?
- How might additional ad inventory coming onto the market affect prices and margin? At what level will inventory growth boost the overall market, and when will it just lead to lower prices?

Contributing author:
Nikolaus Lehmann

6. Semiconductors

Semiconductors, sometimes called microchips or integrated circuits, are the invisible building blocks of the digital world. Their ubiquity and importance were highlighted during the COVID-19 pandemic, when a surge in demand led to supply shortages of not only computers, smartphones, and other consumer electronics but also of cars and household appliances, all of which rely heavily on microchips.[136] In the early years of the 21st century, as semiconductor manufacturers chased smaller and smaller distances between chips' transistors, a disaggregated business model appeared, with some "fabless" companies designing chips and other companies specializing in manufacturing them in factories called "fabs." Those shifts made the industry one of today's arenas, as we describe in chapter 1. From 2005 to 2020, its revenues grew by a CAGR of 7 percent.

The industry could be one of tomorrow's arenas, too. Some recent technological trends, such as AI, machine learning, robotics, and autonomous driving, are likely to boost demand for complex, domain-specific chips. Generative AI (gen AI) is expected to generate 0.2 QFLOPs (quettaFLOPs) of computational demand in 2024.[137] By 2030, demand for gen AI computational power alone could increase to 25 QFLOPs, an annual rate of growth of about 125 percent.[138] And increasing global prosperity is likely to continue to drive demand for electronics in developing markets. The semiconductor industry is investing heavily in R&D and manufacturing: total capital expenditures increased at a CAGR of 16 percent from 2015 to 2022, though there was a dip in 2023.[139] Furthermore, many governments, including those of China, the European Union, and the United States, are offering the industry significant subsidies to bolster domestic manufacturing.

Growth

Increased demand in several markets could drive the growth of semiconductors. About 80 percent of this growth could come from four market segments: computing and data storage, automotive, wireless communications, and industrial electronics (exhibit). This industry could continue to escalate R&D and capital expenditures to efficiently meet rising demand, as seen by continuous node resets and the emergence of fabs. In our modeled scenarios, the semiconductor industry's revenues grow from $630 billion in 2022 to $1.7 trillion in a lower range of scenarios in 2040 and to $2.4 trillion in a higher range of scenarios, a CAGR of 6 to 8 percent.[140] In those scenarios, prices increase by an average of about 2 percent a year, and supply and demand are balanced in the long run (though there is often some shorter-term volatility, as a result of boom-and-bust cyclicality and the impacts of other factors such as the COVID-19 pandemic).

Note: This section describes the potential growth and dynamism of the ***semiconductors*** *arena. It should not be read as a comprehensive account of the industry. To learn more about semiconductors and associated industries, please refer to content from the McKinsey Industrials & Electronics Practice.*

Exhibit

The data storage, wireless, automotive, and industrial electronics segments drive overall growth in the global semiconductor market.

Semiconductor industry revenue by segment, $ billion

Segment	Share of 2022–40 increase, %	Revenue CAGR, 2022–40, %	Share of 2022–40 increase, %	Revenue CAGR, 2022–40, %
Wired communications	9	8	7	9
Consumer electronics[1]	8	5	6	6
Industrial electronics	14	6	13	8
Automotive	23	10	19	11
Wireless communications	22	5	19	6
Computing and data storage	24	4	37	8

Note: Figures may not sum to 100%, because of rounding.
[1]Consumer electronics consists mainly of non-mobile devices (eg, TVs, smart speakers, smart bulbs, set-top boxes).
Source: Omdia; IDC; McKinsey Global Institute analysis

McKinsey & Company

Computing and data storage. In our scenarios, revenues from semiconductors that are used in this segment grow from $230 billion in 2022 to between $480 billion and $890 billion in 2040, a CAGR of 4 to 8 percent. Most of that growth would be fueled by demand for semiconductors used in servers, though chips for PCs, storage, and peripherals would also play a part.

The higher end of these scenarios yields the $890 billion market size and is based on the following underlying dynamics:

— The AI and cloud services industries grow very quickly and need servers to support them (see "Cloud" and "AI and software services" in this compendium). For example, Nvidia's data-center-specific revenue grew 427 percent in the first quarter of 2024 compared with the first quarter of 2023, with 87 percent of the company's overall revenues attributable to data-center solutions.[141] Industry leaders have already signaled their intention to sharply increase AI investment: Google's DeepMind is expected to surpass $100 billion in total AI spending, and Microsoft and OpenAI are reportedly considering building a supercomputing cluster worth $100 billion.[142]

— Demand continues to increase for higher-value chips for servers, such as graphic processing units and AI accelerators, which are now employed mostly by cloud services companies and high-performance computing users.

— Demand for computing in developing countries rises quickly as their economies grow.

In the lower range of these scenarios, which yields the $480 billion market size, the magnitude of each of these factors is lower: the AI and cloud services industries grow less quickly, the higher-value chips for servers do not reach spending parity with standard ones, and demand for computing in developing countries grows less quickly.

Automotive. In our scenarios, revenues from semiconductors used in vehicles grow from $60 billion in 2022 to between $300 billion and $390 billion in 2040, a CAGR of 10 to 11 percent. While overall automotive demand rises modestly over this period, averaging about 1 percent a year, growth is primarily driven by the increasing value of semiconductors in the average car, which was $600 in 2022 and by some estimates could reach $1,400 by 2028. That increase, in turn, is driven by three trends. The first is a growing share of electric vehicles, which can need roughly ten times as many semiconductors as traditional vehicles, on average. In addition, traditional vehicles are increasing their use of semiconductors. Second, driving assistance features, which require sensors and computing power, become more common. Third, cars' "infotainment" systems grow increasingly sophisticated, including more head-up displays, digital instrument clusters, and rear-seat entertainment.

Wireless communications. In our scenarios, revenue from chips used in wireless devices grows from $180 billion in 2022 to between $400 billion and $500 billion in 2040, a CAGR of 5 to 6 percent. About half of that growth comes from increasing demand for smartphones, particularly as they become more common in developing economies. The rest of the growth comes from chips used in other wireless devices and infrastructure. Actual revenues in 2040 will depend on how rapidly people shift to mid-tier, high-tier, and 5G-enabled smartphones, which use more expensive semiconductors.

Industrial electronics. In our scenarios, revenues from semiconductors used in industrial electronics grow from $75 billion in 2022 to between $200 billion and $300 billion in 2040, a CAGR of 6 to 8 percent. These semiconductors are used in a variety of industries that are expected to grow quickly, such as medical electronics, industrial automation, and electricity generation from renewable sources.

Dynamism

The semiconductor industry has four major types of players: fabless designers such as Nvidia, which design chips; foundries such as TSMC, which manufacture them; integrated device manufacturers (IDMs), such as Intel and Samsung, which do both; and companies such as ASML that sell specialized manufacturing tools to the foundries and IDMs. The semiconductor industry features a few large players, and companies that offer better or cheaper products typically hold a majority of the global market. This is especially clear in specific technology segments along the value chain. For example, in 2022, ASML captured 87 percent of the $18 billion worldwide lithography equipment market;[143] Intel, 78 percent of the $62 billion market for central processing units; Nvidia, 84 percent of the $20 billion market for graphics processing units; TSMC, 63 percent of the $107 billion foundry market; and Samsung, 37 percent of the $144 billion memory segment.[144] These five segments make up more than half of total semiconductor market revenues.

Although the industry seems likely to continue to feature a few large players, companies' market share could be changed by a move, already under way, from general-purpose to domain-specific chips. The shift derives from the growing popularity of fast-growing applications for semiconductors, such as machine learning, 5G, and the Internet of Things. For those uses, domain-specific chips can help reduce energy consumption. The adoption of these chips could increase the share of the market held by fabless designers, which could provide a larger portfolio of solutions.

The move by tech companies outside the industry to design their own semiconductors instead of buying them could also shift market shares. Apple has designed processors for its mobile devices and, more recently, for its computers. Meta and Alphabet have designed chips to suit their requirements. And Tesla is designing chips for autonomous driving. If this trend persists, these tech companies could capture market share from the fabless chip designers such as Nvidia. Although huge share shifts in chip manufacturing will likely be harder, given the large amounts of capital required to compete with TSMC in the global chip foundry market, it is reasonable to expect increased competition in this space as geopolitical considerations drive countries to diversify their chip-manufacturing supply chains.[145]

Swing factors

— How will evolving national policies and geopolitical shifts affect regional and global markets?

— What will happen to the market for AI-specific chips as incumbents, cloud services companies, and start-ups try to gain market share?

— How long can the current pace of technological advancements and step changes in semiconductor capabilities be expected to continue? What impact could a potential slowdown of innovation (for example, a disruption to Moore's law) have on chip prices, computing performance, and research advancements?

Contributing author:
Ani Kelkar

7. Shared autonomous vehicles

Shared autonomous vehicles (SAVs) are road vehicles that have no human driver and can be hired to transport passengers for a fare. The industry is in its infancy. However, many companies are designing purpose-built SAVs, and several are already road testing regular vehicles enabled with autonomous technology.

The SAV industry's rapid technological development is a sign that it could become an arena. Although autonomous vehicles were first tested in academia in the 1960s, development took off with the DARPA Grand Challenge contests starting in 2004. SAV development has been led by companies such as Apollo (owned by Baidu), AutoX, Cruise (owned by GM), Pony AI, and Waymo (owned by Alphabet). Robo-taxis are already in service in some US cities, such as Phoenix and San Francisco, and in China in the cities of Beijing, Chongqing, and Wuhan.[146]

Furthermore, from 2010 to 2021, more than 400 companies—mainly venture capital and private equity firms, followed by big tech and automotive OEMs—reported a total of more than $100 billion in investment in robo-taxis and robo-shuttles.[147] Although venture capital and R&D investments in SAVs in the United States fell from a peak of $25 billion in 2019 to $3 billion in 2022, the mobility industry more broadly has experienced an uptick in investments from late 2023 into 2024.[148] Recent investments in the SAV industry have included Alphabet's plan, announced in July 2024, to invest an additional $5 billion in its autonomous technology provider, Waymo.[149] This variable investment sentiment suggests that commercialization in the industry may go more slowly than some previous forecasts had indicated.

Growth

The potential for outsize growth in the SAV arena is based on sustained technological progress, a compatible regulatory environment, the financial feasibility of broader adoption, and consumer acceptance. The broader shared mobility industry changed dramatically in the first decade of the 21st century as regional and multinational tech companies, beginning with Uber, began competing with traditional taxi companies by offering ride-hailing services. As of 2022, taxis still garnered 58 percent of the industry's global revenues of $1.2 trillion, while ride-hailing services took in 14 percent. The remainder was earned by car-sharing and car-rental services, shuttle services, and micromobility services, such as those that let people rent bicycles from curbside racks. We exclude the revenues of mass transit operators from our definition of the industry.

In our scenarios, SAVs could capture 25 to 51 percent of the shared mobility industry's revenues by 2040, taking market share from human-driven taxis and ride-hailing services. Because the pace of technological development and adoption of SAVs is uncertain, our range of estimates for the industry's revenues in 2040 is wide: between $610 billion and $2.3 trillion (Exhibit 1).

*Note: This section describes the potential growth and dynamism of the **shared autonomous vehicles** arena. It should not be read as a comprehensive account of the industry. To learn more about SAVs and associated industries, please refer to content from the McKinsey Automotive & Assembly Practice, and the McKinsey Center for Future Mobility.*

Exhibit 1

The shared autonomous vehicle industry's revenue could grow to $610 billion–$2.3 trillion in 2040.

Global market for shared and micromobility ground transportation,[1] $ billion

[1]Market data excludes private cars and public transit.
Source: McKinsey Center for Future Mobility (May 2024); McKinsey Global Institute analysis

McKinsey & Company

To estimate the industry's potential size, we considered the revenues that it could earn by transporting passengers in fully autonomous vehicles, which have what the industry calls level four or level five automation.[150] Such vehicles might include robo-taxis or robo-shuttles. We excluded autonomous vehicles that would not run on roads, such as trains, and those that would fly (which we discuss in the entry "Future air mobility"). We also excluded personal vehicles, even though many of them might have automated driving systems by 2040.[151]

Several factors will determine the industry's revenues in 2040.

The first factor is technological progress. Significant obstacles stand in the way of operating self-driving cars safely and reliably. Teaching cars to identify objects, people, and animals on roads is a challenge, and so is making sure that the vehicles can continue navigating in bad weather. Although companies are making impressive headway, some of the challenges remain, because the array of circumstances that will need to be taken into account will grow over time as SAVs spread to increasingly complex and unpredictable environments.[152] As a result, SAVs are likely to first emerge in the center of cities, which offer the highest density of potential passengers, and find cities where weather conditions are less likely to cause issues for sensors.[153] Unforeseen problems can arise, even

in the areas that have already been selected. SAVs need to anticipate accidents and be equipped to respond to them.

Second is the regulatory environment. There are myriad unanswered social and political questions: how would liability for accidents be distributed between SAV manufacturers, operators, and riders? Do we measure the safety of an autonomous vehicle versus a human driver, or should a different standard be applied? What vehicle registration process would be mandated for SAVs, and what powers should law enforcement or government have over the vehicles? Some countries and jurisdictions have started issuing guidelines for autonomous driving.[154] However, globally, regulatory risks continue to be one of the biggest impediments to autonomous-vehicle adoption. In a 2021 survey of executives from automotive, transportation, and software companies, 60 percent said that they viewed insufficient regulatory support, rather than technological obstacles or low demand, as the factor that is most likely to limit the adoption of autonomous driving.[155] In a 2023 McKinsey survey of autonomous-vehicle leaders, the percentage of respondents who said that regulation is the biggest bottleneck for the industry remained at 60 percent.[156]

A third factor that will determine the industry's revenues is financial feasibility. Deploying SAVs at scale requires significant capital investment, and considerable outlays are needed to attain profitability. The cumulative capital outlay requirement is projected at about $50 billion to $67 billion through 2030.[157] In a capital-constrained environment, commercialization might occur more slowly because only a limited group of profitable markets will emerge. Although the initial price tag is high, the capital required to manufacture SAVs is expected to shrink over time. Some manufacturing costs associated with traditional vehicles could be reduced by eliminating parts that are redundant in an SAV.

In addition to capital requirements, the unit economics of operating SAVs would also dictate the industry's course. In our scenarios, operational costs that are lower than those of alternative modes of transportation would encourage adoption. Once the industry is mature, the cost of a trip by SAV could range from 60 percent less than the cost of using a personal car to 30 percent more, depending on whether a person is traveling alone or pooled.[158] The cost could be 30 to 80 percent lower than using a ride-hailing service (Exhibit 2).[159] The savings result from lower labor costs (because SAVs have no human drivers) and lower fuel and maintenance costs (because computer-directed driving could optimize fuel consumption and reduce maintenance requirements). SAVs do have some operations and management costs that human-driven cars do not, such as remote operations support centers that assist vehicles in emergencies. However, these additional costs are expected to be offset by the lower per-trip cost of SAVs.

Exhibit 2

Travel by shared autonomous vehicles could become cost competitive relative to travel by private car by 2035.

Cost per passenger-mile traveled, forecast for 2035 and beyond,[1] index (1.0 = private vehicle cost)

[1]For shared modes end-customer price per passenger-mile traveled and for private vehicle MSRP share per year and operational costs (eg, maintenance, insurance, charging, cleaning, parking, tolling, financing). Private vehicle cost assumes MSRP of $34,360 and lifetime mileage of 197,106 miles.
[2]Depending on city-specific pricing and trip length.
Source: McKinsey Center for Future Mobility

McKinsey & Company

Fourth, the degree to which consumers are willing to choose shared mobility of any kind will affect the size of the SAV industry. This is influenced by both consumer sentiment and regulations. We estimate that roughly 40 percent of all passenger miles were traveled in shared vehicles in 2022. In our scenarios, that share in 2040 would range from 40 percent in the low case to 60 percent in the high case.[160] The share could be pushed up by regulatory changes in large cities, such as license plate rationing and the imposition of congestion charges.[161] It could also rise if people became less willing to own their own cars for reasons related to convenience, cost, safety, or the environment, for example.

Dynamism

The SAV market is nascent and is likely to show high dynamism as the arena grows. An SAV product needs to bring together three things: the autonomous driving technology, the physical cars, and the shared mobility service that plans trips, logistics, and interfaces with the customer. This makes the industry particularly dynamic as competition emerges from companies that currently excel at each

one, with technology providers, ride-hailing companies, and carmakers approaching the industry from different angles.

The autonomous technology providers, such as Baidu's Apollo, GM's Cruise, and Alphabet's Waymo, are the furthest along today. They plan not only to operate fleets but also to build the technology necessary for autonomous driving. Some of those companies will probably procure vehicles from established carmakers and then integrate software into them; Waymo uses Jaguars, for example. Others, like Cruise, might be owned by carmakers and use vehicles built by their parent company.

Carmakers, too, might play a role by equipping their vehicles with autonomous driving capabilities and then selling them to other companies.[162] Tesla has stated ambitions to enter the SAV market, and Volkswagen aims to supply self-driving vans to ride-hailing companies.[163]

By contrast, ride-hailing companies might end up procuring the technology and cars they need from others. Ride-hailing companies will have various competitive advantages from their experience operating mobility services, including existing reputations, existing customer bases, and developed platforms. For example, Uber has partnered with both Waymo (2023) and Cruise (2024) to make their shared autonomous vehicles available on Uber's platform.[164]

There are significant escalatory factors that create tendencies toward eventual consolidation. The extensive amount of research and development needed to develop autonomous vehicles creates a high barrier to entry for technology providers, encouraging consolidation within the industry and with carmakers. There are also high barriers to entry for operating a shared autonomous vehicle service; as with today's ride-hailing operators, there are strong network effects and cost advantages to scale that encourage consolidation. These factors could create a market led by a few key players along with some smaller regional companies. Similar dynamics have emerged in today's ride-hailing industry.

Of course, the emergence of SAVs would also shift market share in the broader shared mobility industry. We could see a disruption similar to that of the early 2000s, when the shared mobility industry's composition began tilting away from local taxi companies and toward the regional and global ride-hailing companies that offered customers convenience and lower costs. In the same way, SAVs could disrupt the industry by offering customers a cost-effective alternative to ride-hailing.

Swing factors

- How quickly can SAV manufacturers overcome key technological hurdles, such as increasing range and mobility beyond geofencing, reducing reliance on remote interventions, and creating purpose-built platforms that enable positive unit economics?[165]
- How will regulations governing autonomous driving affect the SAV industry? And how will policy makers determine operators' and owners' liability for SAV-related accidents?
- How will the evolution of SAVs affect consumer sentiment and future competition in the market (for example, product differentiation by vehicle amenities)?
- How will the business model differ across the industry's three kinds of companies—autonomous technology providers, ride-hailing companies, and carmakers (for example, different offerings, customer base, and impact of regulations)?
- Will players experience regionalization of their tech stack due to regulations, data limitations, privacy mandates, and restricted access to high-end semiconductors?

Contributing author:
Andrew Sierra

8. Space

Since the first moon landings over 50 years ago, most of the demand for space endeavors has been driven by government interests rather than commercial opportunities. Over the past decade, however, the industry's commercial sector has seen robust growth. Because of this surge of interest, commercial applications like remote satellite connectivity could help make space an arena of tomorrow.

Several space companies have accelerated growth in the past decade. SpaceX, one of the most active commercial service and infrastructure players, provides internet service via its Starlink system—a constellation of more than 5,000 small satellites—and offers launch services (more than 300 launches as of June 2024).[166] In addition, the company is testing Starship, a fully reusable launch system that could carry humans for interplanetary and orbital spaceflight. Other companies have also been exploring space tourism: Virgin Galactic carried passengers to the edge of space and back twice in the first half of 2024 and plans to enter commercial service by 2026.[167] Planet Labs, another space services company, provides imagery of the Earth's landmass several times a day (for example, to enable data-driven agriculture). And Origin Space, a Chinese space mining company, has launched satellites into low Earth orbit to collect debris and assess space resources; it aims to begin commercial asteroid mining by 2045.[168]

Alongside private companies, governments around the world continue to shape the space arena by increasing their investments and deepening their collaborations with private players. For example, NASA awarded multibillion-dollar contracts to three private companies to develop competing designs for a lunar terrain vehicle.[169] At the same time, some government-backed missions have succeeded at a relatively low cost: India's Chandrayaan-3, which landed on the moon, had a $74 million budget—less than was spent on some Hollywood space movies, such as *Gravity* and *Interstellar*, that had budgets of more than $100 million.[170] More nations are entering the space race, too. For example, Saudi Arabia is seeking to diversify its economy by promoting scientific research and boosting national security via space, while Peru has launched the "Internet para Todos" program to enhance internet connectivity in rural regions using satellites.[171]

Four key trends have transformed the space industry over the past decade and are helping to pave the way for space products and services to become ubiquitous.

First, launch costs have decreased exponentially. For example, when adjusted to 2021 dollars, low-Earth orbit heavy launch costs have declined by more than 95 percent, from $65,000 per kilogram in 1980 to $1,500 per kilogram in 2021.[172] Second, commercial innovation makes it possible to do even more in space. Commercially available applications now allow for identification of objects on Earth at a resolution of 15 cm, a 20-fold increase compared with an initial resolution of three meters. Third, investment is flowing from a wider group of investors to a larger and more diverse set of applications. Private-sector investment in space is reaching all-time highs, with more than $70 billion invested in 2021 and 2022 combined.[173] Fourth, there is excitement over, and interest in, the latest space developments, with government and business leaders considering what space could enable for the future.

Growing investment and interest in space could dramatically change our lives by helping to address a wide range of challenges. For example, space-based Earth observation could help identify infrastructure risks by monitoring structures, such as dams and nuclear power plants. Developments in satellite data and analytics could transform disaster relief efforts by providing real-time information to shorten response time during humanitarian crises, quickly identify affected populations, and optimize coordination of first responders and evacuations.

*Note: This section describes the potential growth and dynamism of the **space** arena. It should not be read as a comprehensive account of the industry. To learn more about space and associated industries, please refer to content from the McKinsey Aerospace & Defense Practice.*

Space-based capabilities could also help bridge current digital divides separating developed and developing nations by providing access to high-speed internet, education, and healthcare services. And space technologies could provide precise monitoring of agriculture, natural resources, and environmental changes. The advancements not only would bring financial gains but could also help alleviate global challenges like climate change and hunger.

Growth

The space industry consists of two segments, commercial and government. Over the past decade, the space industry has been tightly linked to government policies. With growing commercialization and expansion of downstream services, the space industry could produce strong growth in both segments.

These two segments each divide into two subsegments. The commercial segment consists of the services and end-user equipment subsegment, and the infrastructure and support subsegment; and the state-sponsored segment is divided into the civil subsegment and the defense and intelligence subsegment (exhibit).

Exhibit

The space arena is divided between the commercial and state-sponsored segments.

Segments and subsegments of the space industry

Commercial		State-sponsored	
Services and end-user equipment	**Infrastructure and support**	**Defense and intelligence**	**Civil**
Communications tools for mobility in remote areas, internet connectivity, commercial positioning and navigation, satellite networks, and rocket launch services	*Satellites, ground stations, rockets, and support services to maintain space operations*	*Military-run missile defense systems, positioning and reconnaissance, satellite-based surveillance, and intelligence gathering*	*Projects by civil space agencies (eg, NASA, ESA) such as Global Positioning System and risk response*
39–51% of market in 2040[1]	**11–18%**	**22–32%**	**16–22%**
Example companies			
SpaceX, Amazon, Eutelsat, Planet Labs, NEC Space, Mitsubishi Heavy Industries	SpaceX, Airbus, Lockheed Martin, Blue Origin, Axiom Space, Mitsubishi Heavy Industries	Lockheed Martin, Raytheon, Boeing, General Dynamics, ThyssenKrupp, Northrop Grumman, China Aerospace Science and Technology Corporation	Boeing, Lockheed Martin, Northrop Grumman, SpaceX, Airbus, Arianespace, BAE Systems,[2] China Aerospace Science and Technology Corporation

[1]Middle range scenario.
[2]Includes Ball Aerospace (acquired 2024).
Source: McKinsey Global Institute analysis

McKinsey & Company

For all four subsegments, we considered the industry's "backbone," which includes satellites (such as those used for space-based communications), launchers, services such as satellite TV and GPS, and applications with revenues that are directly attributable to space hardware and service providers. A report by McKinsey and the World Economic Forum published in April 2024 describes this backbone in greater detail.[174] The report also looks at a "reach" component, defined as the wide range of industries that are or would be enabled by the space backbone's solutions and services but are not a direct product or service of a space provider. Reach services include delivery providers like Uber Eats that leverage satellite signals, and logistics companies like Amazon that use space data to monitor and optimize fleet traffic. In this article, we focus on the backbone solutions and services that are core to the space arena, but we note that the reach component is a critical driver of demand for the space economy.

In our scenarios, the space industry's revenues grow from $300 billion in 2022 to $960 billion by 2040 in the lower range of scenarios and to $1.6 trillion in a higher range of scenarios, a CAGR of 7 to 10 percent.[175] The commercial segments of the industry may grow between 6 and 9 percent a year from 2022 to 2040, and the state-sponsored segments may grow at a slightly faster pace, between 7 and 10 percent a year, as countries accelerate investment in the space race.[176] In 2023, revenues were $330 billion (62 percent from the commercial segments and 38 percent from the state-sponsored segments).

The commercial services and end-user equipment subsegment, including communications and commercial positioning, navigation, and timing (PNT) solutions, is projected to grow from $180 billion in 2023 to between $420 billion and $690 billion in 2040 (a CAGR of 5 to 8 percent). Communication services will likely remain the largest source of commercial revenue, with new constellations extending the reach of satellites to meet demand for connectivity in remote areas that aren't covered by existing technology. Aided by large constellations, such as SpaceX's Starlink and Amazon's Project Kuiper, the data price for commercial satellite communications has decreased rapidly; a Euroconsult report estimated a 77 percent decline in data prices in the five years through 2024.[177] As these constellations progressively reach full deployment, the decrease in data prices could continue, albeit at a slower rate. At the same time, lower cost, reduced latency, and greater coverage could increase the demand for data by 60 percent (in gigabits per second) between 2023 and 2035 as consumers seek affordable options for remote connectivity.[178]

PNT solutions are likely to continue to build on free signals from state-sponsored satellites to provide commercial positioning and navigation. This service could continue to grow as more people adopt smartphones and sport watches (three billion devices with GPS receiver chips could be manufactured every year by 2035, up from two billion today).[179]

The commercial infrastructure and support subsegment is projected to grow from $22 billion in 2023 to between $120 billion and $220 billion in 2040 (a CAGR of 10 to 14 percent) as growing space investments help accelerate the deployment of commercial infrastructure to support the demand for space services and as companies continue seeking greater space presence and scale.

This subsegment will likely have two major tailwinds for growth.

First, satellites are becoming cheaper, as technological advancements increasingly allow constellations to be built from small units at scale. This, in turn, promotes more manufacturing to enhance connectivity and observation capabilities.

Second, infrastructure players are developing reusable heavy rockets, which can launch satellites at a lower cost per kilo of payload. Launch costs have already decreased significantly and could decrease 40 percent more between 2023 and 2035.[180] Growth in this subsegment could be driven by the reusability and increase in size of the vehicles, which improve launch economics.

State-sponsored investments, including in the defense and intelligence and civil subsegments, are likely to remain the cornerstone of the space arena's expansion over the next 20 years, with continued growth spurred by incumbents and new entrants. Government agencies are expected to remain key customers, especially for high-end products and services.

The state-sponsored civil subsegment is projected to grow from $59 billion in 2023 to between $180 billion and $270 billion by 2040 (a CAGR of 7 to 9 percent) as it benefits from increased efforts to develop new use cases of space assets. Many organizations have only explored the surface of space applications and are creating strategies to increase impact. For example, the European Space Agency is seeking to engage potential partners in three areas: sustainability, economic growth, and resilience on Earth and in space. New, tailored space applications could enhance research, risk anticipation, and disaster response efforts. For example, when Tropical Cyclone Idai landed in Mozambique, the British Geological Society was able to use satellite data to produce a hazard classification of rainfall-triggered landslides that was then used by civil protection teams to bolster disaster relief efforts.[181]

In addition, many countries are seeking to improve their space capabilities. The number of space agencies has grown from 40 in 2000 to more than 75 today.[182] For example, the United Arab Emirates created a space agency, launched a mission to the International Space Station, and sent a probe to Mars within a decade. India has also expanded its space presence and became the fourth country to land a spacecraft on the moon in 2023 after a failed attempt in 2019.[183] The country is increasing its space efforts with the goal of launching a solar observatory and supporting entrepreneurs in the private space and satellite sector.

The state-sponsored defense and intelligence subsegment is projected to grow from $66 billion in 2023 to between $240 billion and $410 billion in 2040 (a CAGR of 8 to 11 percent) as nations increase spending to strengthen their national security and autonomy. While the United States spends about twice as much on space programs as the next ten countries combined, other nations are beginning to increase their expenditures.[184] China, in particular, has achieved an approximately 20 percent CAGR in estimated space outlays, compared with about a 12 percent CAGR in the United States from 2018 to 2023.[185] According to a report by the US Space Force, Defense Innovation Unit, US Air Force, and US Air Force Research Laboratory, China "continues to compete toward a strategic goal of displacing the US as the dominant global space power economically, diplomatically and militarily by 2025."[186] These trends will likely add weight to requests to allocate more funding to space programs.

In all four subsegments, varying trajectories of technological evolution and the ability of players in the space arena to achieve scale and wide adoption could determine whether the market size will be closer to the lower range of scenarios or the higher one.

In our higher estimate of the space industry's revenues, we assume that improved access to data collected from space and the standardization of that data may create new revenue streams, particularly for software application and analytics players. For example, aggregating and classifying space data with user-friendly and easily distributable structures could improve access. Data of this kind could enable use cases for non–space players, such as feeding the data into AI to better manage a supply chain network. At the same time, cost reductions across the value chain from space-vehicle manufacturing to ongoing space data reporting may accelerate adoption and the accessibility of the space economy.

In the lower range of scenarios, we assume that cost curves stay steady as economies of scale take longer to achieve, hindering expansion of space-related activities. In addition, while examples of terrestrial alternatives are limited, future technological advances could be viable substitutes for traditional space-based solutions, affecting continued interest in sectors such as satellite communications and navigation.

The development of new space technologies over the next two decades could unlock revenue potential in a number of reach industries beyond the backbone segments in the space arena, such as transportation and logistics.[187] In many cases, services that improve product quality and access as well as drive efficiencies will likely be created or enhanced by leveraging space-based data. For example, data from satellites that powered the global rise of the ride-hailing service Uber could enable faster and more efficient last-mile delivery for perishable goods, food, and beverages. We estimate the range of the potential revenues of these space-enabled applications to be $1.4 trillion to $2.6 trillion by 2040.

Dynamism

The space arena has drawn increasing interest from the private sector. More than 600 start-ups are operating in the arena, up from 250 in 2010.[188] In the past decade, about 1,800 companies worldwide have received private equity investments of about $290 billion, according to Space Capital.[189] The top three companies by revenue represented roughly 10 percent of the entire market in 2023.[190] Escalatory patterns of investment, however, may lead to barriers to entry that favor early movers: for example, the first companies to send large-scale constellations to space for communications would be able to provide broader network coverage more quickly, harness network effects, and garner greater customer adoption. This race to the top for scale and a presence in space, coupled with expensive launch and infrastructure costs, could eventually limit the number of companies that can sustainably thrive on the space value chain (with some exceptions for specific space-based services). Barriers to entry include the need for substantial investment in R&D capabilities to innovate and demonstrate capability, compliance with stringent regulations, and the high risk of capital loss if space projects fail. Besides these dynamics that could limit the number of players, there are a limited number of buyers in certain segments of this industry.

Market dynamics, however, vary by subsegment.

The commercial services and end-user equipment subsegment presents the lowest barriers to entry and will likely have the most players. A large number of specialized use cases allows for entry of new players that cater to specific sectors. For example, data analytics companies could leverage the use of space monitoring capabilities in a wide range of industries that have distinct needs such as agriculture and logistics. Data analytics companies with access to satellite data could help a transportation player enhance its mobility services by improving tracking and management of vehicles, reducing costs, minimizing downtime, and improving operational efficiency. Spire Global, for instance, uses a constellation of orbital nanosatellites to track ships at sea, allowing maritime companies to directly monitor their locations.[191] Data analytics companies focused on weather services can help anticipate and mitigate risks along transportation routes, minimizing delays and ensuring safety of delivery personnel. Players can leverage a broad array of data and capabilities and can tailor a unique value proposition to compete, leading to a more fragmented market that continues to see new entrants.

The commercial infrastructure and support subsegment has fewer players than commercial services and includes companies such as SpaceX, Airbus, Lockheed Martin, and Blue Origin. Projects in this subsegment require significant R&D activity to succeed, raising barriers to entry. Companies that can reduce manufacturing costs and create new capabilities—with technology such as reusable launch vehicles—will likely gain an edge over competitors by managing launch processes more efficiently. For example, within the next two decades, the emergence of super-heavy rockets led by extensive R&D efforts at SpaceX could disrupt the subsegment by significantly reducing launch costs and lowering the number of launches needed. Super-heavy launches could capture about 70 percent of commercial launch market revenue, excluding the Chinese market, by 2035.[192] The number of players could decline as small launch providers face competitors that offer lower launch costs using super-

heavy rockets. As a result, rocket manufacturing and launch services may become industry segments where a few large players have a majority of market share.

The state-sponsored civil subsegment also has high barriers to entry. Boeing, Lockheed Martin, Northrop Grumman, BAE Systems, China Aerospace Science and Technology Corporation, and SpaceX are examples of companies operating in this space.[193] Compared with the defense and intelligence subsegment, the civil subsegment offers more opportunities for players to enter because it covers a broader range of applications beyond just defense and intelligence, including scientific research and disaster management. This creates more diverse spaces for players to occupy, though civil services would still be government-funded and face strict mission requirements. For example, private companies other than defense and intelligence contractors can enter the industry via partnerships with government entities for use cases such as disaster response.

The state-sponsored defense and intelligence subsegment of space has relatively fewer players. They include Northrop Grumman, Lockheed Martin, Boeing, and Raytheon. Traditionally, larger players have benefited from a deep understanding of the contracting process and the resources to navigate it. This advantage could persist for established companies, especially those with cutting-edge defense technology, strong engineering, and extensive contracting capabilities. However, as certain market segments become more fragmented, opportunities are emerging for new entrants, particularly smaller players in specialized niches. Procurement strategies are also becoming modular and agile, fostering increased competition and new avenues for growth. Moreover, the industry is shifting from constructing a small number of complex satellites toward larger satellite constellations with smaller units, which could create opportunities for new entrants.

Swing factors

- How might commercial interest in space continue to evolve and shape future innovation and commercially viable business cases?
- How could new space data services increase the number of use cases and have an impact on various industries?
- How would geopolitics affect the structure and distribution of the global market?
- How might the role of government or government-backed organizations evolve? How could procurement and safety policies on both a national and an international level affect the subsegments differently?

Contributing author:
Jeffrey Caso

9. Cybersecurity

The cybersecurity industry protects computer systems—computers, networks, cloud and web applications, network-connected manufacturing equipment, programs, and data—from unintended and unauthorized access, modification, or destruction. Unlike other software industries, this one owes its existence to a set of determined adversaries, including private hackers seeking ransom and nation-states advancing geopolitical goals. Because those adversaries keep improving their capabilities, the cybersecurity industry has no choice but to do the same.

Indeed, one indication that the cybersecurity industry could become an arena is that cyberattacks are becoming more frequent, complex, and costly. Marketplaces for hacking tools and data are growing. Generative AI (gen AI) has reduced the cost of mounting ransomware and phishing attacks. In addition, ransomware-as-a-service represents a growing threat. In these systems, developers provide tools to affiliates who lease them to malicious actors in exchange for a cut of the ransom. As the technical barrier to entry for cybercriminals has become lower, smaller firms have been increasingly exposed to attacks. In 2020, the full economic cost of cybercrime, including direct, indirect, and upstream systemic costs, was estimated to be in the range of $4 trillion to $6 trillion.[194]

The recent high level of innovation is another indication that the cybersecurity industry could become an arena. From 2017 to 2021, the number of patents issued increased at a CAGR between 15 and 71 percent in three younger segments of the industry (cloud security, security operations and management, and cybersecurity for the Internet of Things and operational technology) and between 15 and 20 percent for two more mature segments (data protection and network security). The rate of patent issuance in technology overall was only about 8 percent.[195]

Growth

In our modeled scenarios, the cybersecurity industry's revenues could grow from $160 billion in 2022 to $590 billion in the lower range of scenarios in 2040 and to $1.2 trillion in the higher range of scenarios, implying a CAGR of 8 to 12 percent.[196] The share of all IT spending devoted to cybersecurity could grow from 6 percent in 2022 to between 7 and 14 percent by 2040.

In our low estimate of the industry's revenues, cybersecurity spending increases only slightly more quickly than all IT spending.[197] In our high estimate, cybersecurity spending as a share of total IT spending doubles between 2022 and 2040. Our range of estimates is based on the extent of the following factors.

First, attacks continue to increase, encouraging companies to spend more on protection.

Second, the digital landscape continues to grow and change, broadening the attack landscape. Clients use more and more devices and apps, all of which need protection. They also generate more data, a great deal of which needs to be analyzed by cybersecurity companies to protect sensitive information. As a result, the responsibilities of the typical chief information security officer become far more expansive.

Third, as the need for cybersecurity increases, new business models make the technology more appealing and accessible to small- and medium-size clients. Traditional consumption-based pricing models (which, for example, charge by the number of gigabytes of logs analyzed) work well for companies that have a sophisticated understanding of their needs and that are large enough to secure volume discounts. Smaller clients could be more likely to use newer pricing models. These include outcome-based models, in which the price of a cybersecurity product is based on meeting predefined levels of protection, and attack surface-based models, in which the price is based on the

*Note: This section describes the potential growth and dynamism of the **cybersecurity** arena. It should not be read as a comprehensive account of the industry. To learn more about cybersecurity and associated industries, please refer to content from the McKinsey Digital Practice and the Technology, Media & Telecommunications Practice.*

number of servers or workloads protected. For these models to be profitable, cybersecurity providers might have to rely on AI to do much of the work.[198]

Fourth, cybersecurity-related regulations continue to increase. These often impose requirements on certain companies that create incentives for them to spend more on cybersecurity.

The extent of the impact of those four factors will help determine the industry's actual revenues in 2040. For example, if geopolitical conflicts were to intensify, cyberattacks by nation-states could increase, boosting the need for governments and companies to spend on cybersecurity. The achievement of technological breakthroughs in such areas as AI and quantum computing could broaden the attack landscape more quickly. So could faster-than-expected adoption of the internet in developing countries.

The cybersecurity industry also faces a major challenge: a global shortage of talent. In 2021, for example, 3.12 million jobs in the industry went unfilled.[199] That shortage could create pressure to use automation and AI to compensate.

Dynamism

The cybersecurity industry is highly fragmented; its ten largest companies generate less than 20 percent of its revenues. Indeed, the cybersecurity industry is the most fragmented of all the possible arenas of the future we have identified in this report. However, cybersecurity could begin to see a few large players develop in individual industry segments over time as businesses scale to remain competitive.

The fragmentation has many causes. For one thing, the industry is highly diverse. It can be divided into 13 segments that address a variety of threats in different ways (see sidebar "The cybersecurity market has more than a dozen niche categories of business"), and those segments can be divided further into about 70 subsegments. Many of the segments, such as endpoint security and cloud security, focus on the protection of a particular technology; others, such as consulting, have a broader purview.

Fragmentation is also the result of differing regulations from country to country.[200] In addition, the role of nation-states in mounting cyberattacks encourages the proliferation of cybersecurity companies in different countries. Threats are constantly evolving and need new technologies to counter them. The barriers to entry for new companies are low. However, solutions that work for one client often need to be suitable for another. For many clients, cybersecurity is a "layered" solution, in which a variety of different products and services leads to better security. The growing shortage of workers with cybersecurity skills makes organizations particularly dependent on layered services to compensate for the lack of talent available.

Nevertheless, a few larger players seem to be emerging as the industry matures, following the well-established pattern of industries built on technical innovation. From 2012 to 2017, the number of new cybersecurity companies increased at a CAGR of 10 percent, and the number of M&A deals increased at a CAGR of 12 percent. From 2017 to 2022, the number of new cybersecurity companies declined at a compound annual rate of 34 percent, while the number of M&A deals kept growing (though more slowly than it had during the previous five years). The apparent decrease in the number of large players could reflect an increase in the scale necessary to compete. For instance, broader use of AI may require big proprietary data sets and higher up-front R&D spending. Also, vendors offering holistic solutions that are integrated among multiple cybersecurity applications may have an advantage, furthering the benefits of scale.

Sidebar: The cybersecurity market has more than a dozen niche categories of business

— *Identity and access management and fraud detection.* Organizations use this process, known as IAM, to manage, provision, deprovision, and adjust user access to critical data, applications, and services. It involves tools across the value chain and allows both employees (a process known as workforce IAM) and customers (customer IAM, or CIAM) to securely onboard and verify their identity. In the fraud detection use case, for example, standard IAM processes are supplemented with additional data such as know-your-customer or KYC programs.

— *Application security.* Many organizations make their own software for internal and external use, and application security is the process by which they manage the security of applications. This includes tooling across the DevOps process, such as application-security testing technology that enables on-demand and continuous scanning of applications for vulnerabilities.

— *Security operations.* Many companies have created security operations centers that serve as the organization's security nerve center. Tooling in this category allows for log collection, ingestion, normalization, and analysis, as well as automation and orchestration tooling that enables incident response.

— *Cloud security.* As organizations pivot to the cloud, additional tooling is required to ensure that cloud environments (such as instances, buckets, and containers) adhere to enterprise security policies. A combination of policy management and technical tooling helps enable security controls across cloud, hybrid, and multicloud environments.

— *IoT/OT security.* There is an emerging market for the security of nontraditional IT devices, including smart appliances, shop-floor robotics, turbines, and more. This category encompasses the security of programmable logic controllers and supervisory control and data acquisition devices. These devices typically prioritize availability for constant runtime and, in many cases, are legacy technologies (both hardware and software) that were not originally designed with cybersecurity attack vectors in mind.

— *Data protection.* This tooling enables the data security and privacy of structured and unstructured data, including data-at-rest, data-in-use, and data-in-motion. It encompasses encryption technology and technology that facilitates encrypted communications, as well as tooling that builds and leverages contextual understanding of data criticality in adopting dynamic security controls.

— *Endpoint security.* This process provides day-to-day security for user hardware, such as laptops, mobile devices, and servers. This category includes antivirus software as well as more advanced technology that push enterprise security policies to endpoints and allow for real-time response to threats across the enterprise.

— *GRC and IRM solutions.* Governance, risk management, and compliance (GRC) and integrated risk management (IRM) are typically functions of security risk organizations (also known as the "second line of defense") that exist within more regulated industries. These tools enable the security risk and compliance process by managing and automating workflows of controls attestation, tracking enterprise risks for centralized reporting, and recording risk appetite and related decisions.

— *Network security.* This tooling operates at the network layer to manage the security and authorization of network resources. It includes technologies such as firewalls, which analyze inbound packets, as well as virtual private networking (VPN), which allows for secure communications within an enterprise network.

— *Web security.* This category encompasses tools that protect the consumption of web resources as more information and applications become web-facing. This includes content filtering in an employee's browser as well as the network traffic management and security of web applications.

— *Email security and security awareness training.* This tooling works with a corporate email system to filter out spam, identify phishing emails, and build user awareness of threats such as spear phishing that are often email-based.

— *MSSP and consulting.* This category encompasses managed security service providers (MSSPs), which are third-party operations that manage security devices and processes. These services can include providing 24/7 security monitoring, specialized skill sets such as advanced forensics for incident response, and outsourcing of commoditized services like identity provisioning and deprovisioning. In addition, these providers offer consulting services such as risk advising and incident response.

— *Implementation.* This category covers the technical setup, configuration, and maintenance of the security stack.

In the future, the trend toward fewer large players could continue within each of the industry's segments, fueled in part by established technology companies. For example, Microsoft has made notable acquisitions (including Two Hat, RiskIQ, and CloudKnox Security) and has promised to invest an additional $20 billion in cybersecurity through 2026.[201] Google has pledged $10 billion to advance cybersecurity solutions over the same period.[202] However, there are important factors that could keep the industry fragmented. The segments perform such different functions that combining them may not make practical sense. Instead, clients could continue to employ the layered approach and diversify risk by using multiple providers, calling on the cybersecurity companies whose offerings are best suited to their particular needs and risk profiles. Furthermore, geopolitical divisions could result in the shattering of a single global internet into parts, sometimes called the "splinternet," which could also discourage industry-wide consolidation.

Swing factors

- As cybersecurity technologies continue to mature, how might new segments emerge, and which segments could become obsolete?
- How might AI affect the cybersecurity industry? Would it chiefly benefit the attackers or the companies that combat them?
- How would the emergence of widespread quantum computing, if it becomes a reality, affect cybersecurity? How quickly could the cybersecurity industry address security challenges brought on by quantum computing, such as the obsolescence of traditional encryption and the development of new pathways for attacks?
- How many geographically distinct markets might the cybersecurity industry encompass, and how might geopolitical developments affect the structure and distribution of the global market?
- How could evolving consumer awareness of digital safety and data security affect the growth of the cybersecurity industry, for example, if cybersecurity becomes more of a competitive advantage for consumer internet companies or if public pressure affects policies or regulations related to cybersecurity?

Contributing author:
Alexandre van de Rijt

10. Batteries

Batteries are key to the energy transition. The battery industry's value chain extends from mining and processing raw materials such as lithium and nickel, to cell manufacturing in gigafactories, to combining cells into rechargeable battery packs used for electric vehicles, stationary storage, and other applications. Batteries enable the electrification of transportation and storage of renewable energy by facilitating the distribution of electricity across space and time. Our analysis focuses primarily on batteries with lithium-ion chemistries, the most versatile and widely used today due to their high energy density and overall decline in cost. We also include sodium-ion batteries, which could scale as alternatives to lithium-ion batteries if lithium prices increase too sharply.

Batteries have come far technologically over the past 30 years. Costs have fallen from thousands of dollars per kilowatt-hour (kWh) in the early 2000s to less than $100 per kWh today, and energy density—a measure of the amount of energy a battery can store in proportion to its weight—nearly tripled in that period.[203]

Batteries are expected to improve further as they achieve higher energy density, accelerated charging, and improved life cycles, and reduce their environmental impact (for example, by using renewable electricity to power the manufacturing process or by sourcing more sustainable raw materials such as green nickel and cobalt). Some of this continuous improvement results in advances in battery technology such as the ability to enrich the anode with silicon compounds. Other advances come from new designs such as solid-state batteries or from new chemistries such as lithium-sulfur and vanadium redox. These could become direct substitutes for lithium-ion and sodium-ion batteries in specific applications (for example, to enable longer-duration storage). Older battery types with lower energy density, such as lead-acid, are excluded from consideration because the focus of battery innovation and market entry is increasingly shifting to novel and fast-growing segments.[204]

The following are the three main end-use segments in this market (Exhibit 1):

*Note: This section describes the potential growth and dynamism of the **batteries** arena. It should not be read as a comprehensive account of the industry. To learn more about batteries and associated industries, please refer to content from the McKinsey Battery Accelerator Team.*

Electric vehicles (EVs): This segment includes passenger cars, commercial vehicles, two- and three-wheelers, and off-highway, railway, marine, and aviation uses.[205]

Battery energy storage systems (BESS): Stationary energy storage systems, including those for utility-scale, commercial, industrial, and residential storage, make up this segment.[206]

Consumer electronics: This segment includes smartphones, laptops, wireless headphones, cameras, and other devices that rely on built-in batteries for power.[207]

Exhibit 1

Electric vehicles could account for 84 to 88 percent of the total battery market by 2040.

Segments of the battery industry

Electric vehicles

Passenger cars, commercial vehicles, 2- and 3-wheelers, off-highway, railway, aviation, maritime

84–88% of market in 2040

Battery energy storage systems (BESS)

Front-of-the-meter (FTM) utility-scale systems, behind-the-meter (BTM) residential, commercial, or industrial systems (eg, EV charging infrastructure)

11–14%

Consumer electronics

Electronic equipment for everyday use, such as laptops, smartphones, TVs, tablets, game consoles, speakers, and headphones

1–2%

Example companies		
BYD, LG, Panasonic, Tesla	BYD, Tesla, Hithium, Sungrow, Fluence	Samsung, LG, Panasonic, BYD

Note: Figures may not sum to 100%, because of rounding.
Source: McKinsey Global Institute analysis

McKinsey & Company

Because batteries are the enabling technology for the global energy transition, the industry is a promising potential arena of tomorrow. Decreasing costs, increasing lifetimes, improvements in energy density, faster charging, and advances in sustainability could expand the range of potential applications and solidify two large demand pools. The first is the electrification of the world's fleet of one billion passenger vehicles. The second is the array of energy storage and power backup solutions that complement renewable energy generation by smoothing and time-shifting supply to more closely match the demand profile. Investors have already started to show confidence in these use cases: venture capital and private equity funds have poured about $42 billion into battery technology through more than 1,700 deals in the past ten years, with 75 percent of the investment in 2020 and 2021.

However, the industry is facing several headwinds, despite strong growth prospects. Global supply exceeds capacity, placing downward pressure on prices. This, combined with the high fixed costs required to build and ramp up a gigafactory, is leading to long-term profitability concerns, which also make financing more difficult. Strong secular demand trends toward electrification still point toward long-term growth, but growth could be tempered as margins shrink and financing becomes scarcer.

Growth

In our estimates, the battery industry produced 760 GWh of battery capacity in 2022, increasing to 12,800 by 2040 in the lower range of scenarios and to 13,700 by 2040 in the higher range of scenarios, a CAGR of just under 20 percent. The battery industry's revenues increase from about $98 billion in 2022 to $810 billion by 2040 in the lower range of scenarios and to $1.1 trillion by 2040 in the higher range of scenarios, a CAGR of 12 to 14 percent.

In all three segments—EVs, BESS, and consumer electronics—growth may be powered by both declining prices (and higher volumes) and increased future innovation. Batteries are still relatively expensive and make up 35 to 45 percent of the total cost of an EV, presenting a hurdle to the mass-market deployment of the vehicles and storage systems. Yet prices are decreasing as production capabilities and capacity improve. Gigafactories are increasing their output and becoming more efficient.[208] The global average battery plant size is expected to increase from 16 GWh in 2023 to 28 GWh in 2030, which is likely to further improve production efficiency. Economies of scale could enable lower yield loss, faster production-line speed, and more efficient use of labor and energy.

Recent decreases in raw material prices and overcapacity in the cell supply have put more pressure on cell prices. And developments in new battery chemistries, for example moving from nickel and cobalt to iron and phosphate, could reduce the use of expensive raw materials. Growth could also be accelerated by a projected 2 to 3 percent annual increase in battery energy density, which would decrease the weight of higher-efficiency batteries, their cost, or both (Exhibit 2). Our sizing of the battery market is based on the projection that average cell cost could decrease from $80–$130 per kWh in 2023 to $50–$75 per kWh in 2040.[209] Prices could fall even lower if nascent technologies such as solid state batteries accelerate.

Exhibit 2

Technological innovation is driving an increase in battery energy density even as production efficiencies reduce costs.

Battery energy density and price outlook through 2035

Source: BloombergNEF 2020 Lithium-Ion Battery Price Survey (for 2016 and 2017 data); McKinsey Battery Insights; McKinsey Global Institute analysis

McKinsey & Company

For now, the three segments of the battery market are positioned for varying levels of growth, depending on tailwinds.

EV batteries: This market is projected to propel future growth of batteries and to make up 84 to 88 percent of demand in 2040. Annual production capacity in the EV batteries segment is expected to increase from 650 GWh in 2022 to between 11,000 and 12,000 GWh in 2040, a CAGR of about 18 percent. Revenues in the EV battery segment are expected to rise from $85 billion in 2022 to between $700 billion and $950 billion in 2040, a CAGR of about 14 percent. Growth would stem from the projected evolution of the market for EVs as passenger and commercial vehicles are steadily electrified.

In 2023, EVs made up 18 percent of global new passenger vehicle sales, with the numbers varying by geography: in China, more than 30 percent of new passenger vehicles were EVs, in the European Union 16 percent, and in the United States 8 percent.[210] According to scenarios modeled by McKinsey's Center for Future Mobility, EVs' share of global passenger vehicle sales grows to between 82 and 96 percent by 2040. In 2023, only 4 percent of commercial vehicles sold were battery electric vehicles (BEVs) and fuel cell electric vehicles (FCEVs). In the scenarios for 2040, the share of BEVs and FCEVs among light-duty trucks and light commercial vehicles would increase to between 30 and 80 percent in regions of low penetration and to between 85 and 100 percent in regions of high penetration, with most of the vehicles likely to be BEVs.

Four main factors are driving battery growth to the higher or lower end of that range: EV cost and quality, consumers' willingness to pay a premium for sustainable vehicles and policy incentives, charging infrastructure, and the supply and distribution of electricity to the charging infrastructure. The EV market has seen some recent slowdowns, such as delayed electrification targets of some OEMs, and in 2024 experts revised EV sales growth projections downward for the first time. The market still displays strong long-term potential, though it is less accelerated than in the vehicles' early years. We discuss adoption of EVs in greater detail in the compendium entry on electric vehicles.

BESS: BESS is the fastest-growing battery segment and may account for more than 10 percent of battery-cell demand in 2040, with global capacity deployment increasing from 50 GWh in 2022 to almost 100 GWh in 2023.[211] That could increase to between 1,600 and 1,800 GWh in 2040, a CAGR of about 22 percent, according to analyses from McKinsey's Battery Insights and Energy Storage Insights solutions. Revenues to manufacturers for sales of BESS could increase from $7 billion in 2022 to between $100 billion and $140 billion in 2040, a CAGR of 16 to 18 percent.

This segment has the potential to enable the renewable energy transition, with growth in both front-of-the-meter installations and behind-the-meter installations.[212] Front-of-the-meter installations—the utility-scale BESS systems installed on the electric grid to store and dispense energy—account for the majority, about 65 percent, of the BESS segment.[213] Growth in utility-scale BESS is driven by both the expansion of renewable energy generation from wind and solar and the development of other energy storage technologies. Greater reliance on renewable energy requires energy storage that can balance out the natural intraday variability in wind and solar energy generation.[214] Utility-scale BESS is growing rapidly as utilities race to find a storage solution for the growing share of variable energy production. In 2023, variable renewables like solar and wind accounted for 13 percent of global electricity generation, nearly double the 7 percent share in 2018. By 2028, that share could rise to 25 percent.[215] Other than storage capacity, BESS also provides ancillary services to support the grid such as frequency regulation, further driving growth.[216]

In addition to intraday storage, renewable grids also may require large amounts of long-duration energy storage (LDES) to meet interday or even seasonal fluctuations in energy supply and demand. Several technologies are being explored, from thermal storage and compressed air storage to hydrogen and power-to-gas.[217] If battery prices continue to drop as LDES develop toward

technological maturity and commercialization, BESS could become a cost-competitive solution for LDES use cases as well.

Behind-the-meter installations—systems installed at residential, commercial, or industrial locations for generation, consumption, and storage—account for the remaining 35 percent of the BESS segment. Although they are a smaller part of the segment, behind-the-meter installations have the potential for growth, alongside distributed power generation resources such as solar panels in homes or office buildings. Behind-the-meter systems can store excess electricity generation during the daytime and help moderate energy costs by reducing peak demand spikes. They can also buy electricity from the grid when prices are low and sell it when prices are high. Residential energy storage (namely, smart homes to achieve energy self-sufficiency and optimize self-consumption) also show growth potential. Technological advances that enhance price, energy density, safety, and ease of installation will likely help push further adoption by businesses and consumers.

Consumer electronics: This market may make up less than 2 percent of battery demand in 2040, rising from 50 GWh in 2022 to about 170 GWh in 2040, a CAGR of about 7 percent. This segment's revenues could increase from $6 billion in 2022 to about $14 billion in 2040, a CAGR of 5 percent, driven by continued growth in portable consumer devices. The consumer electronics industry has been maturing, and incremental advances have slowed. As a result, consumer demand has begun to shift from new to refurbished products that are more affordable and comparable in capabilities. Without further innovation and change, it is likely that demand for consumer electronics would grow at a modest and steady pace, affecting the demand for built-in batteries. That growth in consumer electronics—and the associated batteries—could be driven by the expanding middle class in developing countries, such as Brazil, Egypt, India, and Indonesia.[218]

Dynamism

Today's battery-manufacturing landscape has a few large players and is largely based in Asia. This stems from a first-mover advantage that allowed top players to quickly develop economies of scale and efficient supply chains. As a result, in 2021, the top four cell manufacturers controlled upward of 60 percent of the battery production market for EVs.[219] Japanese and South Korean cell manufacturers tend to be established conglomerates with decades of experience, while Chinese manufacturers started producing consumer batteries and expanding into EVs in the 1990s. Battery producers are still ramping up in Europe and North America.[220]

The battery industry has high barriers to entry given the large capital requirements to build gigafactories and the large operational challenges to ramp up gigafactories. These constraints, together with increasing material cost and tightening global competition, mean thinning margins that could continue to favor the large incumbent global cell manufacturers. For example, lithium-ion batteries currently face pricing pressures as EV sales growth has not kept up with the rising global production and temporary overcapacities exist. In times of tightening margins, smaller manufacturers may have difficulties competing against larger competitors' economies of scale, operational advantages, and ability to take new contracts (and maximize capacity utilization) at a lower price without sacrificing overall financial performance. While prices naturally peak and trough depending on the market's supply and demand, these swings will likely continue to favor industry leaders that are able to weather market lulls.

Moreover, the market may continue to favor scale because the need for technology know-how and supply-chain infrastructure stability could lead to a high-cost ticket to play that discourages would-be entrants and existing players that are unable to achieve sufficient scale. Higher barriers to entry—such as the need for aggressive cost reductions in the manufacturing and procurement of raw materials—could benefit the players with the most scale. This could set the stage for escalation of capital expenditures as players seek to generate greater scale to compete under tight margins. Large

players have significant cash flow to deploy robust research teams to develop battery technology, making it harder for smaller players to compete. In addition, supply-chain challenges give incumbents a head start. Players would likely need to have the know-how to design batteries and optimize manufacturing. To achieve scale and win customers, producers could need to secure machinery capacity, develop long-term supply contracts, and improve product sustainability.

Supply-side factors could also shift global market share from the large Asian players to scaled competitors outside Asia. China has faced overcapacity issues; for example, gigafactory average utilization rates dropped below 45 percent in the first quarter of 2023. A utilization rate of 75 to 85 percent is the typical benchmark for profitability.[221] This is the result of escalatory competition from top players that overinvested in production capacity to try to capture future demand. Trade policy is another important factor shifting market shares in the battery arena, as governments outside Asia increasingly prioritize local battery manufacturers with policy incentives both for cell makers and EV customers, as well as through import tariffs on foreign batteries. For example, the 2021 US Bipartisan Infrastructure Law provided a $3.5 billion boost to domestic battery production.[222]

And there are opportunities for new entrants. Advances in technology and specialization in new use cases could allow new entrants to compete against the incumbent battery manufacturers, which must continually invest in R&D to maintain an edge. These new players could evolve existing technologies, such as semi-solid-state lithium-ion batteries, or they could develop batteries with longer durations than traditional ones. It's not possible to predict whether the new technologies currently under development—such as longer-shelf-duration, higher-density, lower-cost, and fit-for-purpose designs in EV power trains—will be able to reach scale or disrupt the sector. Moreover, new entrants would need to commercialize new innovations faster than existing players to capture the benefits of this higher-risk technology development. But if these new breakthroughs come from players other than incumbents, or if incumbents fall behind on the pace of research, space to compete would open for new entrants with more efficient or lower-cost batteries. These market shifts could tip the scale in favor of certain chemistries and benefit players that meet market needs.

Swing factors

- How will consumer demand and changes in government regulation, including climate-related policies, affect the pace of growth in the battery industry?
- Will batteries be the technology of choice for utility-level energy storage, and how much will that use case grow as countries decarbonize?
- How will a preference for local battery production stemming from geopolitical tensions affect future supply-chain resilience?
- How might newer battery technologies, such as sodium-ion and lithium-sulfur, improve energy density, reduce production costs, and ultimately affect industry dynamics, such as the growth rate by battery segment and the number of new entrants by battery technology?
- How will the sourcing and processing of raw materials change as the industry shifts toward batteries with smaller environmental footprints?
- What is the relationship between prices and the rate of adoption of battery technologies? How would events along the supply chain, for example a spike in the price of a raw material such as lithium or nickel, affect pricing or the adoption rate?
- How will the shift from a linear to a circular industry (use and dispose versus repair, reuse, and recycle) affect the battery market?
- What are the potential constraints for battery growth (for example, the ability to sustainably increase supply of critical minerals for lithium-ion batteries)?

Co-authors:
Jan Mischke,
Dave Dauphinais

11. Modular construction

With a value of $13 trillion, construction is one of the largest industries in the global economy. However, despite technological improvements by individual companies, labor productivity growth in the industry has lagged for decades. Global construction productivity increased only 10 percent (less than 1 percent annually) between 2000 and 2022, while productivity for the overall economy increased 50 percent (2 percent annually) and the manufacturing sector's productivity rose 90 percent (3 percent annually).[223] Construction productivity actually declined 8 percent from 2020 to 2022.

The need for transformation is urgent for two reasons. First, there is a global housing shortage and affordability crisis, especially in populous cities such as Mexico City, Mumbai, New York, and São Paulo that account for more than 20 percent of the world's GDP.[224] The UN Special Rapporteur on the Right to Adequate Housing estimated that about 1.6 billion people lacked adequate housing and 3 billion people could be affected by 2030 due to declining mortality rates, increasing global population, and limited affordable housing options.[225] Second, there is a critical skilled labor gap in the construction industry, especially in the United States. According to one estimate, for every new hire in the American construction industry, there may be 20 new job openings for critical roles such as laborer, electrician, and welder.[226] An additional factor, though not as widely acknowledged, is that the buildings and construction sector accounts for 37 percent of global emissions and faces increasing pressure to reduce its carbon footprint.[227]

Industrialized modular construction has the potential to change the game in the massive global construction industry—which had a market for new builds worth roughly $8 trillion in 2022—by improving construction productivity. In contrast to the long-held practice of in situ assembly of raw materials such as cement and timber, modular construction entails building standardized, prefabricated 2D or 3D modules at an off-site factory. The modules are then assembled into buildings or infrastructure on the construction site. Two-dimensional modules are typically single-discipline units such as precast frames and panels, while 3D modules are volumetric, comprehensive structures. In this report, we focus on 3D modules, which are better suited to achieve the technique's productivity potential.

*Note: This section describes the potential growth and dynamism of the **modular construction** arena. It should not be read as a comprehensive account of the industry. To learn more about modular construction and associated industries, please refer to content from the McKinsey Operations Practice.*

Modular techniques can reduce the time needed for the planning, design, and on-site installation phases of construction. These phases can be run in parallel, while traditional construction requires construction phases to proceed sequentially (exhibit).[228] Modular construction requires fewer workers than traditional building projects, an attractive prospect in high-labor-cost countries such as Japan, the Nordics, and Singapore.

Exhibit

Using 3D volumetric modules can deliver 20 to 50 percent schedule compression.

Example apartment project construction duration, traditional vs off-site 3D volumetric, months

[1]Overruns of 25–50% of projected construction duration are common.
[2]Mechanical, electrical, and plumbing.
Source: Case studies; interviews; McKinsey analysis

McKinsey & Company

However, modular construction has yet to reach scale globally. We estimate that roughly 2 percent of the $8 trillion market for new builds in 2022 used the technique. In North America, the growth of modular construction has been slower than projected, at a 4 percent CAGR from 2018 to 2022, compared with forecasts of 6 to 12 percent. The slower growth can be attributed to inadequate ecosystem partnerships, including with installation contractors, developers, and financers. Common challenges encountered by modular firms include overdesign, inefficiencies in installation, unsteady manufacturing pipelines, and insufficient capital, all of which prevent companies from realizing their promised time and cost savings.[229] By overcoming these challenges, modular construction could completely transform the global construction industry with a step change in productivity. Because of this potential, modular construction could become an arena of the future.

But there are trade-offs. First, modular construction factories need stable demand over long periods to keep busy and running. Second, while module repeatability and ease of assembly reduce on-site

complexity and the need for manual labor, the technique also creates greater logistical complications and requires planning for standardization across various project types, from affordable housing to single-family homes.

Growth

Experts forecast that the modular construction industry could expand substantially over the next ten to 15 years, estimating an annual growth rate of between 6 and 10 percent. Growth could be driven by the increasing global penetration of the process, from about 2 percent of new build in 2023 to a projected 5 to 9 percent in 2040.[230] In our modeled scenarios, the modular construction market's revenues could grow from $180 billion in 2022 to $540 billion by 2040 in the lower range of scenarios, a CAGR of 6 percent. In the higher range, market size could reach $1.1 trillion by 2040, a CAGR of 10 percent, assuming growth continues in regions with higher penetration and less advanced modular markets catch up.[231]

To estimate the growth of the modular construction market, we considered the end-to-end value of an entire project, not just the value added during off-site construction. That is because modular firms typically act as primary designers. However, there are other business models, such as modular manufacturing firms that supply premade units but do not install them. This report disregards single-discipline units, such as precast frames and panels, and concentrates instead on volumetric and comprehensive structures.

Three critical factors contribute to the high and low ranges of estimates of where the modular construction industry will be in 2040.

Partnering across the value chain: In the higher range of scenarios, modular companies coordinate effectively in three major ways. First, they are integrated into project design with developers and architects. This ensures that project specifications are ideal for a modular system. Next, the companies collaborate effectively with suppliers and manufacturers to ensure efficient production. Last, modular players integrate with and lead on-site contractors and logistics providers to ensure that each component is assembled in the correct sequence. Modular's potential for parallel execution of design as well as off-site and on-site manufacturing can be realized only when those processes are carefully sequenced. Delays can cascade if manufacturing rework, late deliveries, or improper assembly diminishes the cost and time savings achieved by a modular project compared with traditional methods. In the lower range of scenarios, these coordination challenges remain an issue in many countries.

Project selection: In the higher range of scenarios, developers source modules for projects that have repeatable units, limited customization, and consistent demand. This does not mean that all modular structures need to look the same. There can be great variation in the aesthetics of modular buildings and in the benefits that can be achieved if there is standardization in the technical interfaces and connections. However, bespoke structures such as corporate campuses that need customized spaces are generally less well suited to capturing the benefits. By contrast, multifamily housing (especially affordable housing) and dormitories are better able to gain from modular construction. Growth in the sector could also depend on whether players can establish partnerships with developers and contractors that ensure a consistent flow of projects, because modular firms rely on constant demand to scale up off-site production factories, given the high fixed capital expenses involved. In the lower range of estimates, modular companies have difficulty finding projects that can achieve the scale to maximize the productivity benefits.

On-site execution: The higher range of scenarios assumes that modular companies successfully leverage experienced construction talent to manage on-site execution. Modular firms with this kind of talent on their teams have an advantage. By investing heavily in tech talent to design and by

innovating on the right product, modular firms could prioritize project execution talent that can train on-site crews and manage deadlines. The labor force on construction sites is accustomed to working with wood and cement. Successful modular firms are those that integrate traditional construction expertise and experience with technical product development. In the lower range of scenarios, these execution challenges remain widespread.

Dynamism

The construction industry is both fragmented and localized, reflecting the many stakeholders and subcontractors involved in any project and the specific construction codes that can vary by location. In the United States, public records list more than 440,000 homebuilder businesses. The largest of these, D.R. Horton, employs 14,000 people and accounts for roughly 10 percent of the market for new homes; the average construction company employs fewer than ten people, and the average construction project involves more than 100 different suppliers and subcontractors.[232]

By contrast, as noted above, modular companies can only realize their full potential at scale, given the high fixed costs of product development and a manufacturing base. Achieving this scale will likely require forming mutually beneficial partnerships with contractors, developers, and other stakeholders in the value chain. Better execution and efficient collaboration could create a cycle of continuous improvement that ultimately could transform the industry.

Even though the industry's growth potential favors players that achieve scale, the forces that encourage fragmentation in the overall construction market limit the number of large players. Different projects have different engineering requirements, equipment and building material needs, and production techniques. As a result, different players specialize in different types of projects or parts of the construction value chain. To get the right materials to the right place at the right time, developers require knowledge of the specific site, and they must be familiar with local regulations and codes as well as local suppliers and logistics. If modular construction becomes a larger portion of the global construction industry, these forces will shape the industry's transformation.

Swing factors

— Despite the continued global housing shortage and skilled construction labor gaps, have high-profile failures of modular construction firms dampened financiers' willingness to invest in the industry? Are national governments likely to intervene to spur the market?

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Contributing author:
Clayton O'Toole

12. Streaming video

The streaming video industry delivers long-form video entertainment over the internet. The global number of households that used these services rose from 320 million in 2017 to 670 million in 2022.[233] By 2040, the number could easily exceed one billion. Over the past decade, escalating spending on content and technology gave rise to a phenomenon known as the streaming wars, as companies vied for consumers' attention and businesses' advertising. More recently, companies have faced increased pressure to achieve profitability, leading to reduced spending and a shift toward the more collaborative business model of content bundling. Although volume growth has moderated in the past few years, the streaming video market still has growth potential. The global number of households around the world with broadband internet reached 1.5 billion in 2023, after expanding at an 8 percent CAGR starting in 2013.[234]

Media and tech players are now trying to determine which content and platforms will attract consumers—whether on smartphones, smart TVs, or dongles that enable streaming on TVs—and how to split revenues. Escalation in this large and growing market explains why streaming video is poised to become an arena of tomorrow.

Growth

The potential drivers of outsize growth in streaming video include increasing adoption of streaming technology worldwide, higher spending on streaming services, and more advertising placements on and revenues from streaming platforms. These growth drivers manifest across the industry's three revenue sources: subscriptions; transactions, such as pay-per-view purchases; and ads, such as YouTube's spots in its free content. As competition and the cost of content creation increase, streaming companies are moving toward generating revenues from more than one of those sources.

Currently, there are five main types of companies. The first type is those constructed entirely around streaming video, such as Netflix. Second are traditional entertainment studios and media and distribution companies such as Disney and Warner Bros. Discovery that have moved into the streaming market by expanding their businesses through forward integration. These players realize most of their profits by offering content on pay TV. Third are big tech companies that have built streaming businesses mainly to enhance their horizontal franchises, as Amazon did with Amazon Prime Video and Apple did with Apple TV. Fourth are video-sharing platforms such as YouTube that offer both short and longer-form content, paid for by subscriptions and ads. While social media companies have video-sharing features, they have been excluded from this analysis, because short-form content tends to serve a different purpose and audience than longer-form videos. YouTube and its $29 billion of ad revenues in 2022 are included, even though the company has a social media component. Lastly, there are hardware aggregators, such as Samsung, LG, and Roku which make streaming devices or smart TVs and aggregate content from multiple providers. For example, Roku, whose user base is larger than the combined audiences of the six largest pay-TV providers, features a set of exclusive free ad-supported streaming TV (FAST) channels.[235] These aggregators also generate revenues from advertising, a factor we included in our calculations. (Hardware sales are excluded from our estimates.)

In our estimates, the industry's revenues grow from $160 billion in 2022 to $510 billion in 2040 in the lower range of scenarios and to $1 trillion in 2040 in the higher range, a CAGR of 6 to 11 percent.[236] A significant portion of those revenues would result from an increase in streaming video's share of the overall video entertainment market. In 2022, streaming video captured only 24 percent of the overall revenues in video entertainment (exhibit). In the middle range of scenarios, that share increases to 43 percent by 2040.

*Note: This section describes the potential growth and dynamism of the **streaming video** arena. It should not be read as a comprehensive account of the industry. To learn more about streaming video and associated industries, please refer to content from the McKinsey Technology, Media & Telecommunications Practice.*

Exhibit

Streaming video could grow to 43 percent of consumer entertainment spending by 2040, up from 24 percent in 2022.

Revenue share among video entertainment industry segments, middle estimate scenario, %

Source: Magna; Omdia; Oxford Economics; McKinsey Global Institute analysis

McKinsey & Company

Three factors underlie the industry growth scenarios:

First, the number of global households that stream video grows from 670 million in 2022 to between 1.0 billion and 1.4 billion by 2040, increasing household penetration from 29 percent to between 34 and 48 percent. The upper range of scenarios assumes that developing markets quickly adopt the technology. The lower range of scenarios assumes that developing markets shift slowly to streaming.

Second, spending on subscriptions and transactions by each household with at least one paid streaming service grows from a global average of $10 a month in 2022 to $20 to $40 a month in 2040.[237] The upper range of our scenarios assumes that developed markets see rapid growth in both the number of households with streaming subscriptions and spending on subscriptions. This might imply not new outlays on entertainment but rather a shift from cable to streaming services. The higher spending by consumers could also include bundled subscription services, such as Disney's bundle of Hulu, Disney+, and ESPN+.

Streaming companies are starting to invest heavily in sports. For instance, Disney+, NBC/Peacock, and Amazon/ESPN signed a $76 billion, 11-year contract with the NBA for exclusive broadcasting rights, and Amazon has acquired exclusive rights to live streaming of the United Kingdom's Champions League soccer matches.[238]

Subscription growth is not unlimited, however. In a 2023 survey, up to 62 percent of US consumers reported that they were overwhelmed by the number of video services.[239] The lower range of our scenarios assumes that the number of new streaming households and their spending on subscriptions are relatively more constrained.

Third, advertising revenues grow at a CAGR of 8 to 9 percent from 2022 to 2040, representing up to half of the streaming video industry's overall revenues. Ad-supported streaming video has grown rapidly: in the United States, it went from 60 million viewers in 2018 to 164 million viewers in 2023, nearly half of the population.[240] Ad-supported streaming video includes both FAST and ad-supported subscription services such as Netflix or Amazon Prime Video's ad-supported tiers. Advertising revenues might continue to increase as ad-supported streaming video viewership increases. The supply of advertising spots in streaming video would also increase as more companies turn to ads for revenue growth, especially in developed markets. However, the ad-supported streaming offerings, which are often free, could pull some viewers away from subscription- and transaction-based streaming video. Our scenarios assume a varying pace of growth for streaming video's share of digital advertising.

Dynamism

The five main types of companies in the streaming video industry—streaming video–first players, entertainment studios, big tech companies, video-sharing platforms, and hardware aggregators—currently have just a few large players. In 2023, Netflix took in 27 percent of global subscription revenues, and the next four largest services (Disney+, Hulu, Amazon Prime Video, and YouTube) accounted for 27 percent combined. Increased verticalization and regulatory decisions could further limit the number of key players. However, the industry may continue to see new entrants, including well-capitalized major media institutions, regional companies, and smaller fragmented creators.

Streaming players have overlapping channels where they deliver their content. For instance, they compete against one another with long-form content streamed on both TV and mobile phones, a growing market that accounts for as much as 16 percent of streaming in the United States.[241] The number of hours global consumers spend taking in media is projected to increase at a 1 percent CAGR from 2022 to 2027, driven primarily by a 7 percent CAGR in digital media usage, led by mobile video and games.

Some of the lines separating products have blurred. Key streaming video players, such as Apple, Amazon, and YouTube, are not traditionally associated with media entertainment and participate in other parts of the attention economy. Also, video—particularly short-form video—is widely delivered by social media companies such as TikTok and Instagram (part of Meta). For example, in 2024, the number of subscribers to the user-generated content (UGC) streamed by the online personality MrBeast surpassed Netflix's global subscriber base.[242] The current market structure was a result of streaming companies' efforts to pursue scale, which provides benefits: while fixed costs (mainly content production and acquisition budgets) are high and rising, the marginal cost of serving additional customers is relatively low. For example, Netflix achieved positive cash flow only when it reached 220 million global subscribers.[243]

The virtuous cycle of benefits that scale brings was observable in the late 2010s, when the companies with the biggest budgets invested in the most content to attract customers, and the companies with the most customers invested more in content. This cycle led to a market structure with a few large players. Nine of the major entertainment studios and media companies in the industry in 2017 had merged by 2022, creating six bigger companies, while all pursuing scale. Companies have moved toward both creating content and distributing it, as Netflix, Amazon, and Apple are doing. Meanwhile, the large studios and media companies have built platforms to distribute their content.

The number of new players has decreased for most of the past decade, while mergers have increased as companies that couldn't match the velocity of investment or build better products were unable to compete and exited the market (an illustration of the escalatory competition described in chapter 2).

More recently, the favorable economics of collaboration has lowered barriers, and companies now see working together as an option for scaling. In addition, companies face stronger pressures for higher profitability (Netflix introduced advertising in 2022).[244] This has moved the market toward greater collaboration, which allows players to license content, bundle streaming services, or rebundle streaming with cable services to save on content creation.

On the other hand, several developments could cause more fragmentation. Regulators could proceed with antitrust challenges to prevent M&A among existing players, or more companies from other industries might enter the fray. Additionally, the advent of generative AI radically lowers the barriers to creating content. It has the potential to reshape the market, including making it easier to produce higher-quality UGC. Companies including Netflix are spending heavily on AI and machine learning to help optimize their production, advertising, and mix of channels and shows.[245]

In addition, some viewers are already watching video-game competitions (commonly referred to as eSports), and video-game companies could use their capabilities to produce video entertainment beyond games. Disney has invested $1.5 billion in an equity stake in Epic Games to form a large-scale entertainment and gaming partnership.[246]

Swing factors

- How will the industry cover content production costs, and which business models (subscription based or advertising revenue based) will succeed?
- How will UGC evolve? To what extent will it replace traditional premium video? Will this evolution vary between short- and long-form content, and how will streaming platforms adapt? How will the lines separating these various forms of media blur? How will ecosystem players with an array of monetization options, such as Amazon and Apple, evolve and become different from pure-play companies such as Netflix?
- How will streaming advertising evolve? What level of adoption will advertiser-supported offerings receive?
- What will the future bundle look like? Could players bundle with other stand-alone platforms, which could enhance users' value proposition? Additionally, how will the shift from cable bundles to unbundled or bundled streaming affect industry dynamics? Who will be in control: cable companies, third-party device makers, tech giants, or entertainment partnerships?

Contributing author:
Andrew Chang

13. Video games

The number of video-game players worldwide increased from 1.9 billion in 2018 to 2.6 billion in 2023. Video games compete for consumers' time in a broader attention economy that offers leisure activities ranging from shopping to social media to streaming video (see the entries for digital advertising and streaming video in this compendium). People born between 1995 and 2010 spend more time playing games than they do watching TV.[247] In 2017, consumers spent only 40 minutes a week on mobile games. By 2022, they were playing almost 100 minutes a week. That could increase to 160 minutes a week by 2027. By 2030, roughly 40 percent of the global population could be video-game players.

Two major trends suggest that the industry could become an arena. First, there has been a surge in game playing on mobile phones. The launch of the iPhone in 2007 and of Apple's App Store in 2008 fundamentally changed the landscape and business model for mobile gaming. In 2017, there were an estimated 1.2 billion mobile gamers. By 2022, there were 1.6 billion. In addition, the mobile gaming market is still relatively young and has considerable potential for expansion.

Second, free-to-play games have been extraordinarily successful on consoles, PCs, and mobile phones, generating revenue from large bases of users who make small but frequent in-game purchases. Spending on games grew from $52 billion in 2017 to $75 billion in 2022, a CAGR of 8 percent. Fortnite, one of the most popular free-to-play games, has 500 million players and generates billions of dollars in revenues for its publisher, Epic Games.[248]

Spending on developing console and PC games has also increased sharply. In 2018, the offerings with the highest budgets and production values, known as AAA games, cost between $50 million and $150 million to produce. By 2023, AAA games with planned releases in 2024 and 2025 had budgets of $200 million or more.[249] By contrast, the average production budget for the 150 most expensive movies from 2016 to 2023 was $180 million.[250]

The video-game industry has recently faced challenges. During the pandemic, limited entertainment options led to increased consumer spending on games, but projections that revenue growth would be sustained after the pandemic proved overoptimistic. The global market has been stagnating due to a reduction in the number of games, challenges in monetization per gamer, recent regulatory changes, and cooling investor interest. Furthermore, cross-platform play, growth in emerging markets, and growth in user-generated content (UGC) and indie titles have challenged the model that worked so well in the high-growth pandemic years. Industry players also face rising competition from vertically integrated competitors, well-capitalized entrants, and global competitors. Consumer spending fell to $57 billion in 2022, near prepandemic levels.[251]

Despite these recent setbacks, the long-term trends surrounding video games are likely to persist. These tailwinds do not imply uninterrupted growth but indicate that if the industry can overcome its current challenges, it could capitalize on these trends to become an arena.

*Note: This section describes the potential growth and dynamism of the **video games** arena. It should not be read as a comprehensive account of the industry. To learn more about video games and associated industries, please refer to content from the McKinsey Technology, Media & Telecommunications Practice and McKinsey Digital.*

Growth

Outsize growth in video games could result from increases in the number of game players—particularly as the number of connected middle-class consumers in emerging markets increases—along with growing advertising revenues and greater spending per gamer as time spent playing increases. Top-performing industry players increase their numbers of users by expanding cross-platform capabilities, investing in high-growth markets, enhancing their platforms, and maintaining

product quality. To sustain profitability, they also take advantage of alternative monetization methods and ad strategies, and they use generative AI (gen AI) technology to improve productivity and lower costs, particularly in game production.

Video games' revenues of $230 billion in 2022 accounted for 35 percent of the total for the overall video entertainment industry, behind traditional video (cable and broadcast TV and movies in theaters) at 41 percent. Video games' share could increase to 44 percent by 2040, the largest in the industry, outstripping streaming video as well as traditional video (Exhibit 1).

Exhibit 1

Video games could grow to 44 percent of consumer entertainment spending by 2040, up from 35 percent in 2022.

Revenue share among video entertainment industry segments, middle estimate scenario, %

Source: McKinsey analysis incorporating data from Magna, Omdia, and Oxford Economics

McKinsey & Company

In our estimates, the video-game industry's revenues grow to $550 billion in 2040 in a lower-range scenario and to $910 billion in 2040 in an upper-range scenario, implying a CAGR of 5 to 8 percent.[252] The calculation of revenues excludes consumer spending on peripheral devices, hardware with different uses (such as phones and laptops), community platforms and streaming, and e-sports (organized video-game competitions).

The 2040 estimates reflect the video-game industry's three revenue segments: consumer spending on games, advertising revenue, and sale of consoles.

Consumer spending on games. This segment includes in-store and digital sales, in-game purchases (also known as microtransactions), and subscriptions to game services, such as Xbox Game Pass and EA Play. It generated about 60 percent of the industry's revenues in 2022.

Developments affecting the size of the gaming population and the amount spent per player will determine future spending. To begin with, gamers are becoming more diverse across platforms, a trend that increases their overall number. This effect is strongest in mobile games, which are attracting more women and older players: in 2022, an estimated 55 percent of mobile gamers in the United States were women, and almost 60 percent of adults aged 35 to 54 played at least once a week.[253] Even those who spent the most time playing PC or console games increased their time spent on mobile gaming. This segment is also growing rapidly in developing economies, especially in Southeast Asia, the Middle East, and North Africa, as internet and smartphone penetration increases.

Expansion of the game-playing population also correlates with the growth of the middle class in developing countries, a group that will have greater access to broadband internet, electronic devices capable of running games, and disposable income to spend on both. The number of players has grown especially quickly in Asia, and other developing regions could follow suit. Asia was home to an estimated 1.5 billion gamers in 2022, and that could grow to 2.7 billion by 2040, a CAGR of about 4 percent, with Southeast Asia showing the most rapid growth. The number of gamers in the Middle East and North Africa is also rising rapidly. Developed economies may experience slower but stable growth, though a new wave of expansion in the number of gamers is still possible if innovations, such as cloud gaming or augmented reality and virtual reality (AR/VR) gaming, become more widespread.

The introduction of UGC, which effectively transforms game players into developers and transforms developers into publishing channels, is also contributing to the increase in players.[254] For example, Roblox users can create games and experiences on its platform and can play games made by other users. By the end of 2023, Roblox had nearly 70 million daily active users, including more than half of Americans under 16.[255] And Fortnite's UGC mode, Fortnite Creative, now has more players than the game's more traditional Battle Royale modes.[256]

Cloud gaming could also increase the amount of time and money that players spend on gaming. Processing of these games takes place in the cloud, and the resulting video can be streamed to any device with hardware and an internet connection that is strong enough to render the images. That lowers the barrier to entry for consumers, gives users access to a wider library of games through subscriptions, sidesteps the need to wait for large downloads, lowers hardware costs, and allows users to play PC-quality games on their phones or other devices.

Gen AI has also become increasingly important in game development. It can be used to generate game content, including voices, dialogue, and personalities for characters. Game developers also have increasingly partnered with the owners of the intellectual property (IP) of popular franchises, from movies to manga, which attract large fan bases. In 2023, 43 percent of the top 200 games in the United States were IP-based. The share was 66 percent in Japan.[257] IP-based collaborations have boosted the number of daily active users of games by 11 percent within the first seven days of launch.[258]

The upper range of revenue scenarios assumes stronger effects on the total number of players based on those factors, and the lower range assumes weaker ones.

These scenarios are also based on assumptions about spending per player. Free-to-play mobile games with in-app purchases can generate more than twice the revenues of mobile games that only require a single initial purchase. This higher scenario assumes that free-to-play formats become even more popular and increase spending per player. It also assumes that subscription models continue

to spread, which would spur consumer spending. Free-to-play and subscription games are growing quickly, but the industry's revenues would be closer to the lower-range scenario if that growth slows.

In addition, the advent of AR/VR could make games even more interactive. If they are widely adopted, they could expand the industry, but their high prices could be a barrier to consumers. Indeed, the technology has already gone through several cycles of hype and bust.

While we do not include e-sports (video games played competitively for spectators) in our sizing of this industry, they are an important factor boosting the popularity of gaming. The market's revenues are projected to increase from $1.2 billion in 2017 to $5.7 billion by 2028, a CAGR of 15 percent. E-sports betting would contribute more than half of projected overall revenues in that period.[259] In 2024, there will be an estimated 286 million e-sports enthusiasts, with an additional 292 million occasional viewers, up from 194 million and 200 million, respectively, in 2019.[260]

Advertising revenue. Advertising in games generated about 30 percent of the industry's revenues in 2022. Estimates of future growth assumed conservatively that these revenues would increase at the same rate as advertising revenues in other digital media.

But revenues could grow more quickly than estimated for several reasons. For one, developers are finding more opportunities for revenues from placing ads in games. For another, games played on mobile phones are the fastest-growing segment, and they are the most likely to use ads: advertising revenues from mobile games climbed at a 30 percent CAGR from 2017 to 2022. By 2027, advertising revenues from mobile games could reach $140 billion, exceeding revenues from paid applications ($110 billion) and in-app purchases ($2 billion).

Games remain a far smaller and newer market for ads than, for example, internet search or TV, so digital advertising has ample room to grow. Ad placements could start to emerge in PC or console games, not just in mobile games.

Sales of consoles. Sales of consoles such as Nintendo's Switch and Microsoft's Xbox generated just 7 percent of the video-game industry's revenues in 2022, a share that could shrink over time. The next generation of consoles is expected to come out in 2029 and could produce a spike in sales followed by a steep drop. Cloud gaming may even make consoles obsolete for the next generation by removing the need for a dedicated local gaming machine. The upper range of scenarios assumes that consoles will maintain their relevance. The lower range of scenarios assumes that players shift to cloud gaming and games on mobile phones, lowering demand for next-generation consoles.

Dynamism

The video-game industry has a few large players; its five biggest companies accounted for about 40 percent of industry revenues in 2022.[261] A sign that the industry may be heading toward even fewer players is that the number of M&A deals surpassed the number of new companies in 2022 for the first time in at least a decade (Exhibit 2).[262] The following year, Microsoft made the largest deal in its history with the purchase of Activision Blizzard.[263] But games for dedicated consoles, PCs, and mobile phones, a fast-growing and currently highly fragmented market, are likely to show different kinds of dynamism.

Exhibit 2

The video-game industry could have fewer players if M&A and new company trends continue.

Number of new companies and M&A deals in the video-game industry

Source: McKinsey Global Institute analysis incorporating data from PitchBook Inc. Analysis not reviewed by PitchBook analysts.

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Recently, a few large publishers in the console-games industry used acquisitions of game developers to scale. Vertical integration of the industry also increased as console manufacturers (particularly Sony, Nintendo, and Microsoft) acquired game developers and publishers to produce exclusive content and expand the value of their ecosystems. Vertical integration also allowed console makers to expand margins, from 5 to 6 percent in the console business and from 25 to 35 percent in game publishing. The trend toward a few large players could continue if new technologies such as virtual reality increase costs further. However, gen AI could pose a threat to incumbent game developers by making it easier for newcomers to create sophisticated games.

A similar trend toward narrowing the field could affect AAA PC games, whose increasing budgets and complexity have also benefited big developers. Indeed, the biggest developers, such as Electronic Arts, produce AAA games for both consoles and PCs. Higher costs may prompt companies to reassess the growth potential of those games, including by examining average user engagement and purchases. This could reinforce movement toward a few players in this high-end segment of the industry, potentially benefiting big developers equipped to handle the cost and complexity. But the market for other PC games is likely to remain more fragmented because developing them is much easier, cheaper, and more open than developing console games, a process that is tightly controlled by the console company.[264]

Mobile gaming may grow faster than console and PC games, and thus exhibit more dynamism. Mobile games already earn more revenues than console games, increasing dynamism across the entire arena, and the enormous mobile-phone market gives this segment ample room to expand, with even faster growth that could raise market share to more than 80 percent by 2040.

The market for games played on mobile phones is currently highly fragmented, but it is showing some indications of consolidation. Small developers can build games for platforms such as iOS and Android, grow rapidly, and try to take market share from incumbents. Movement among the large players has already begun; examples include the acquisition of mobile-first developer Zynga by Take-Two and the purchase of King by Activision Blizzard.[265] In addition, there has been a substantial increase in M&A by mobile native publishers (examples include Playtika's $1.2 billion M&A budget and Stillfront's acquisition of studios to generate economies of scale). While the free-to-play, microtransaction-based business model has been growing—and with it the quality and quantity of free-to-play games—the cost of acquiring paying users is also increasing.[266] That could lead developers that are unable to acquire paying customers to be absorbed by more successful gaming companies.

Swing factors

— Could regional differences lead to supply- and demand-side fragmentation? On the supply side, could there be regional game developers? On the demand side, as internet connectivity improves across the world, will newly connected consumers have differing preferences and follow different usage patterns than their counterparts in developed economies?

— Casual gaming, especially on mobile phones, is driving significant growth in video games. Will casual games continue to take share from other sources of entertainment?

— Will AR/VR technologies that promise next-generation gaming experiences attain widespread commercial success? Although the Oculus Rift was first released in 2016, VR games remain a small part of the market. Will Apple's Vision Pro and other new hardware bring VR to a wider audience?

Contributing author:
Ani Kelkar

14. Robotics

We define robots as programmable machines that automate physical tasks.[267] Industrial robots have been performing a growing number of functions since the early 1960s, when Unimation installed a robot on an assembly line at a General Motors plant in Trenton, New Jersey, where it helped make door and window handles, gearshift knobs, light fixtures, and other automotive hardware.[268] Today, technological advancements in robotics are accumulating, lowering barriers to adoption. Improvements in robot dexterity and mobility have enabled the machines to handle a greater variety of tasks. Robot-assisted surgery helps doctors perform delicate procedures with greater precision, flexibility, and control. In agriculture, robots are taking on environmental problems, such as reducing pollution.[269] Restaurant chains have begun to deploy robots to automate some kitchen tasks. And labor shortages in retail and service jobs create further incentives for businesses to consider their use.

Technological advances in manufacturing processes and scale have driven down the cost of robotics hardware, while advances in software technology have improved the ability of robots to work with humans and enhanced quality through consistency. Advances in generative AI (gen AI) are speeding the development and training process and enhancing the flexibility of general-purpose and humanoid robots. For example, Figure has partnered with Open AI to develop AI-powered humanoid robots, using large language and behavioral models.[270] There has been a surge in interest in these machines. While their resemblance to humans evokes science fiction (and the "uncanny valley" phenomenon), the practical potential benefit of humanoid robots is that anything designed for people—such as machinery, work areas, and other spaces or objects—would not need to be retrofitted to accommodate them.[271] That could ease integration of the machines once the technology capabilities are fully developed.

The robotics industry is benefiting from a large influx of investment capital. From 2018 to 2022, venture capital investment in the field increased from $4.6 billion to $13.1 billion (a 23.3 percent CAGR), with much of the funds going to start-ups such as Covariant, an AI robotics company that raised a $75 million Series C round in April 2024.[272] The Chinese start-up Unitree Robotics raised a $139 million Series B round in February 2024. And established players in other markets are entering the robotics sector via M&A and investments (for example, Hyundai Motor Group's acquisition of Boston Dynamics in 2021, Amazon's stake in Agility Robotics in 2022, and Figure's $675 million Series B round that included investors such as Microsoft, OpenAI Startup Fund, Nvidia, Amazon Industrial Innovation Fund, and Jeff Bezos).[273]

As a result of these investments, robots could play an increasing role in our lives. Some notable recent developments include Amazon's deployment of humanoid robots in a warehouse in Seattle, robot butlers providing room service deliveries in hotels, Google's use of large language models to develop robots that can help with a broader range of everyday tasks, and the announcement by Nvidia in March 2024 that it planned to launch a general-purpose foundation model for humanoid robots.[274]

*Note: This section describes the potential growth and dynamism of the **robotics** arena. It should not be read as a comprehensive account of the industry. To learn more about robotics and associated industries, please refer to content from the McKinsey Industrials & Electronics Practice.*

Growth

The outsize growth potential of robotics would be supported by technological advances and robotic solutions' ability to automate physical work. Attaining the financial, social, and regulatory conditions that would allow mass adoption will also be key factors. Robotics is a broad and complex industry that can be understood through robot types, use cases, and the end markets they serve. The wide spectrum of robot capability includes agricultural automation, industrial robots in

factories, and even autonomous consumer vacuums. The growth of single-purpose robots over the past 20 to 30 years was largely driven by industrial automation, particularly in manufacturing environments and increasingly in warehouses. This segment has experienced stable growth, with an established value chain of original equipment manufacturers, system integrators, and software players adding capability.

Unimation's first installed robotics system attempted to be general purpose but required a highly structured environment where everything had to be in the right place before the robot could be programmed. More recently, the industry has made substantive progress in the development of more autonomous general-purpose robots, which can now execute a variety of tasks with limited human intervention or physical modification of hardware. Through AI and adaptive control, they can even sense their surroundings, reducing the need for environmental control. Additionally, advancements in haptic technology facilitate enhanced picking and manipulation.[275] Boston Dynamics, Tesla, Figure, Google, and Sanctuary are all working on autonomous general-purpose robots that can take on tasks currently performed by people, such as unloading boxes in a warehouse.

To model the growth of robotics as a potential arena, we analyzed the possibilities for automating physical work activities currently done by people, based on McKinsey Global Institute research on scenarios of workforce automation and the report *The economic potential of generative AI*.[276] This is a conservative scope, given that some robots are being used and could increasingly be used to perform activities that are beyond the physical capabilities of people, such as lifting much heavier objects than a person can.

The entire robotics industry, which is largely made up of industrial robots, automated guided vehicles, and autonomous mobile robots, had $21 billion in revenues in 2022.[277] In our scenarios, in 2040, revenues for the entire industry could grow to $190 billion in a lower range of scenarios and to $910 billion in a higher range of scenarios, a CAGR of 13 to 23 percent.

Our analysis estimated the revenue opportunity for robotics solutions by assessing the technical automation potential of 658 detailed work activities (DWAs) and three physical performance capabilities (fine motor skills, gross motor skills, and mobility) in 776 occupations.[278] We then modeled adoption over time, including by comparing the declining cost of technology with hourly wage levels in each occupation in 47 countries that make up more than 80 percent of the world's workforce.[279] We started with the total potential revenue baseline as the cost of human labor attributable to each DWA, which is calculated by multiplying volume (number of hours spent on an activity) by the cost (per hour) of a task. We then estimated the adoption potential of a technologically automated solution for that activity, based on S-shaped adoption curves for similar solutions, assuming that adoption of robotics does not begin until its cost is at parity with the cost of human labor. For each activity, slower and faster adoption scenarios were modeled to range the potential market for automating that activity. This analysis was aggregated for different points of adoption and different wage rates across countries.

Our scenarios incorporated the pace and extent of the adoption of robotic solutions according to four key factors: first, the technical automation potential of physical capabilities; second, the time needed to develop solutions for activities requiring physical capabilities; third, the economic feasibility of automation; and fourth, the pace of adoption, which includes differing levels of business investment, regulation, and social acceptance (exhibit).[280]

For the first factor, the model assumed that the automation potential of physical capabilities hinges on whether robotic technology has achieved the proficiency required to successfully execute a given physical task. Technical automation potential must necessarily precede adoption because robots can be deployed only after they match or outperform humans in the physical activities being automated. To gauge the opportunity presented by workforce automation, robotics researchers were surveyed to

Exhibit

Depending on the pace of adoption of robotic solutions, 40 percent of physical work done by people could be automated in less than 20 years.

Share of time currently spent on physical work activities that could become automated, %

[1]Aggressive scenario for all key model parameters (technical automation potential, integration timeline, economic feasibility, and technology diffusion rates.
[2]Parameters are set for later adoption potential.
Source: O*NET; McKinsey Global Institute analysis

McKinsey & Company

derive a range of the time it would take robots' gross motor skills, fine motor skills, and mobility skills to reach the equivalent of median and top-quartile human performance.[281] Our higher-range scenario assumes these levels of capability are reached at the earlier end of these estimates, while our lower range of scenarios assumes that they are reached at the late end of these estimates, leading to delayed automation potential of relevant work activities.

Perhaps surprisingly, minor tasks that are straightforward for people can be an impediment to robots' ability to work without supervision, lengthening the timeline for full automation of these tasks. For example, specific actions such as tucking in the corner of a bedsheet present obstacles to developing fully independent cleaning robots, even those that are capable of performing the majority of skills needed to clean a hotel room. A robot that can pick an apple from a tree may be unable to harvest strawberries, because the consistency and shape of the stem of each berry are different. Our higher range of scenarios assumed that the technological capabilities allowing robots to tackle these bottleneck skills would be in place by 2040, resulting in higher levels of automation for each task. The lower range of scenarios accounted for the possibility that the bottleneck skills would delay full automation, with a correspondingly lower task automation adoption rate.

The second factor was the speed at which robotic products that solve specific problems might be developed. Our higher range of scenarios assumes that integration of discrete capabilities into solutions occurs more quickly, decreasing the time to market. Our lower range of scenarios assumes

longer timelines to integrate the technologies that transform specific capabilities into solutions that automate work activities. For example, a robot that can automate harvesting activities would need to have a wide range of skill sets to both work with a variety of produce and identify the type of produce.

Third, we assume that innovative automation solutions would have to be economically feasible for users to adopt them. To make the substitution of physical automation for human labor economical, robots need to improve productivity compared with humans, for example by matching human speed on a single shift. Namely, we posit that adoption of robots for a given activity could begin only when the cost of automating that activity is equal to or less than the human labor cost for the same activity at the same level of skill.

Robotics can provide other benefits besides labor cost savings, such as addressing labor shortages (Europe, for example, is facing a declining labor supply, with the workforce projected to shrink by 13.5 million people, or 4 percent, by 2030), increasing throughput, decreasing downtime, and creating a safer workplace.[282]

Finally, mass adoption of robotics solutions will likely depend on several financial, regulatory, and social factors that would influence the rate of deployment. Our higher range of scenarios envisions accelerated customer deployment of robots as people become more comfortable with working alongside the machines, investment to create a workforce that embraces automation for productivity gains, and government regulation in support of robots in the workplace. In addition, our higher range of scenarios assumes that consumers would fully embrace mass adoption of robots and a high degree of integration between humans and robots in daily interactions. In our lower range of scenarios, robots could be deployed at slower rates for several reasons, including social hurdles such as limited support for retraining workers, financial limitations such as delays in capital investment, and a lagging and limiting regulatory response that contributes to uncertainty or headwinds for the industry's long-term outlook.

Dynamism

The robotics arena is likely to display high dynamism as the use of robots expands from traditional industrial applications, such as manufacturing and materials handling, to service applications, such as cleaning, cooking, and maintenance. The dynamism could also be driven by the availability of even more applications through autonomous general-purpose or humanoid robots. Humanoid robots could complete difficult or dangerous warehouse tasks; monitor remotely distributed field assets such as power and telecommunication lines; assist healthcare professionals in physical tasks, such as moving patients and delivering equipment; and perform risky construction work.[283]

In the traditional single-purpose industrial robotics segment, long-established players, such as ABB, Fanuc, and Kuka, are leading a relatively stable, mature market. There is some potential for competitive shuffling as companies such as Denmark's Universal Robotics try to create collaborative "co-bots" that work side by side with people, but generally, the industrial robotics segment is likely to continue with just a few large players.[284] Conversely, newer segments, e.g., autonomous general-purpose robots, could see high levels of dynamism. Tech-forward players are creating several types of machines, including mobile, quadrupedal, and humanoid robots, as well as high-density storage automation.

Moreover, the convergence of gen AI and robotics could dramatically improve robots' abilities to interact with the physical world and perform complex real-world tasks, as a report by McKinsey's Operations Practice points out.[285] By incorporating AI-based large language models and large behavior models, robot control systems can help the machines understand and respond to verbal input as well as mimic human movement. This nascent market features many up-and-coming disruptors vying to be first to launch a workable product, which requires heavy investment in R&D

and a long runway reliant on venture capital funding. Boston Dynamics, Figure, Sanctuary, Tesla, and ANYbotics are early players in this segment, while several global players are emerging in Asia, such as Unitree, SinoRobotics, and DEEP Robotics.

The autonomous general-purpose robot market is likely to show high dynamism, but it also is likely to have fewer large players over time. The massive amounts of research and data needed to develop and manufacture the machines will likely benefit the players with the deepest pockets and largest scale. For example, in August 2022, Hyundai Motor Group—which acquired a controlling stake in Boston Dynamics in 2021 in a deal valued at $1.1 billion[286]—announced an initial $400 million investment to launch the Boston Dynamics AI Institute,[287] dedicated to developing the next generation of machines at the intersection of AI and robotics. And, as with other AI-related products, the additional data that a company with robots in the field can use to make even better robots will likely build barriers to entry for new players.

Yet even though the wider autonomous general-purpose robotics market has fewer large players, there may be a burgeoning and much more fragmented market for robots with specific end markets and use cases. For example, Tortuga uses commercial harvesting robots to help farms automate harvesting, forecasting, and pest treatment, and Blue Ocean Robotics develops, produces, and sells service robots for tasks such as cleaning, disinfection procedures, and patient rehabilitation. This segment could show high dynamism alongside fragmentation, given the huge variety of use cases—there are as many potential use cases as there are specific physical tasks that humans are paid to perform. As long as companies can find a viable business model, there can be more new entrants.

Use-case-specialized robotics players and autonomous general-purpose robotics players are operating in nascent markets that will likely show high dynamism, while the traditional industrial players operate in a more mature market environment. However, the boundaries between these segments are not sharply defined. The traditional industrial players may expand their offerings into some of the use-case-specialized end markets as these markets mature. Over a longer horizon, autonomous general-purpose robots might replace use-case-specific machines if the technological development of autonomous general-purpose robots is sufficiently advanced for them to take on a variety of use cases that are served today by specialized players at lower cost. And there are other applications of robots beyond our scope of automating human labor, for example deep sea and space exploration. These aren't captured in this growth analysis, but to the extent that they are new applications and new technology solutions, they could develop high dynamism, too.

Swing factors

- What other technologies might accelerate the development of robotics? For example, gen AI is enabling faster training of robots, better semiconductors are accelerating computing power, and better batteries are enabling longer activity periods.
- What new tasks will robots be able to perform that are beyond the physical limitations of humans today? How much productivity might this unlock?
- Apart from physical labor, how quickly will robots be capable of providing emotional labor and caretaking? Will consumers accept robotic caregivers?
- How might policies related to labor issues affect the adoption of robotics?
- How might potential market fragmentation caused by geopolitical developments lead to a regionalization of the robotics tech stack?

Contributing author:
Tom Brennan

15. Industrial and consumer biotechnology

Industrial and consumer biotechnology is the use of genetic engineering to analyze and manipulate biological processes at a molecular level to create bio-based products for industrial and consumer purposes. This field could have transformative effects on society as companies develop revolutionary products such as drought-resistant crops, at-home genetic testing, and specialty chemicals manufactured in sustainable and cheaper ways by genetically engineered microbes.

The field has made huge strides over the past 20 years. Several advances have enabled the commercialization of gene editing, including automated genetic sequencing (to "read" genetic code) and CRISPR, a technology that can be used to selectively modify DNA (to "write" genetic code).[288] Research on CRISPR started in 1987, and the full CRISPR-Cas9 gene-editing system was published in 2012. The team that developed the technology was awarded the Nobel Prize in 2020. The precision and applicability of CRISPR-Cas9 was a step change that enabled the wide-scale commercialization of gene editing today. Using CRISPR and similar tools, scientists can edit genes with extraordinary precision. This capability could upend established markets or create entirely new demand in many areas, including cultivated meat and personalized beauty products, among many others.

Biotech has recently encountered investment headwinds: in 2023, industrial and consumer biotech start-ups raised $2.1 billion, down from $4.9 billion in 2022.[289] However, start-up funding in most industries outside of AI also decreased, with global investments declining 38 percent between 2022 and 2023 (while funding to AI increased 9 percent).[290] Despite this recent volatility, there are many reasons to believe that the industrial and consumer biotech sector has the fundamentals to exhibit promising growth and dynamism in the long term.

Growth

The drivers of potential outsized growth for industrial and consumer biotechnology are specific to different segments, but they include demand for more resilient, personalized, and environmentally friendly products, consumer comfort and regulatory support for genetically engineered products and associated data collection, and technology advances to boost resource efficiency and bring costs down. Additional growth enablers include technology advances to accelerate R&D, efficient commercialization, governmental investments, and demand for sustainable products.

We analyzed four significant biotechnology segments in our sizing of the industry: agricultural biotechnology, alternative proteins, biomaterials and biochemicals, and consumer products and services (exhibit). We excluded biopharmaceuticals and sustainable biofuels, both of which we discuss in chapter 3. In our estimates, the industry's revenues grow from $140 billion in 2022 to $340 billion in 2040 in the lower range of scenarios and to $900 billion by 2040 in the higher range of scenarios, a CAGR of 5 to 11 percent.[291]

Note: This section describes the potential growth and dynamism of the ***industrial and consumer biotechnology*** *arena. It should not be read as a comprehensive account of the industry. To learn more about biotechnology and associated industries, please refer to content from the McKinsey Industrials & Electronics, Agriculture, Chemicals, Consumer Packaged Goods, Life Sciences, and Sustainability Practices.*

Agricultural biotechnology. This segment's revenues are projected to grow from $56 billion in 2022 to $170 billion in 2040 in the lower range of scenarios and to $230 billion in 2040 in the higher range of scenarios, a CAGR of 6 to 8 percent.

The pace of agricultural biotechnology's adoption could depend on three factors. First, its use could accelerate if it offers a resource-efficient way of addressing the growing global population's food needs. Global calorie demand could increase more than 30 percent between 2020 and 2050, and production, especially in developing economies, would need to almost double. At the

Exhibit

Continued innovation could accelerate growth in four segments of industrial and consumer biotechnology.

Segments of the nonmedical biotechnology industry

Alternative proteins	Agricultural biotechnology	Consumer products and services	Biomaterials and biochemicals
Cultured meat; microbial protein (eg, mycoproteins)[1]	*Genetically modified animals and crops that help disease resistance, yield, etc; selective breeding of crops and animals through genetic markers*	*Personalized genetic insights; personalized beauty, health, and wellness products (eg, DNA-based diets, personalized skincare); microbiome-based products (eg, probiotics)*	*Bioplastics (eg, PHAs or polyhydroxyalkanoates); fermentation-based chemicals (eg, ethanol; 1,4-butanediol; lactic acid); bio-based additives to food, feed (eg, enzymes, probiotics); microbial crop protection*
10–50% of market in 2040	**30–42%**	**10–29%**	**10–19%**
Potential 2040 revenue, $ billion			
24–390	170–230	71–170	70–100
Example companies			
Upside Foods, Vow	Bayer Crop Science, Syngenta	23andMe, PROVEN Skincare	Danimer, Genomatica, Corbion, Novozymes

[1]Cultured meat is produced by cultivating animal cells directly. Mycoproteins are plant-based proteins derived from a natural microfungus, *Fusarium venenatum*.
Source: McKinsey Global Institute analysis

McKinsey & Company

same time, there is mounting pressure to reduce agriculture's land use intensity. This includes environmental efforts to protect rainforests and other nonagricultural lands, as well as concerns about the increasing use of agricultural land for nonfood purposes such as biofuels.[292] Agricultural biotechnology could alleviate these pressures by increasing yields. For example, field tests conducted from 2014 to 2017 in corn-growing areas of the United States showed that genetically modified hybrids typically yielded 3 to 5 percent more grain than conventional plants, and in some cases, up to 10 percent more.[293]

Second, biotechnology can help develop crops that withstand adverse factors such as pests, droughts, and floods, which could become more frequent in an era of climate uncertainty. For example, *Bacillus thuringiensis* (Bt) crops are genetically modified to contain endospore toxins of the bacterium, making them resistant to certain insect pests. By 2023, adoption of Bt corn in the United States reached 85 percent, more than double its 40 percent adoption rate in 2006.

Third, consumer resistance to genetically modified foods could slow adoption of biotechnology. Significant movements in North America, Europe, and around the world are lobbying to restrict or ban the use of the technology in the food system. Concerns revolve around the potential for allergenicity, antibiotic resistance, and a spillover of genetically modified plants into conventional crops that could reduce biodiversity. The European Union has long had strict regulations on genetically modified

crops, though there has been recent movement toward permitting techniques such as gene editing.[294] Activists have protested India's approval of genetically modified mustard, and an attempt to introduce genetically modified maize seeds to Kenya in 2022 was blocked by legal challenges.[295] The policies and regulatory frameworks that result from these growing movements may affect the adoption of the technology.[296]

Alternative proteins. This market's revenues are projected to grow from $2 billion in 2020 to $24 billion in 2040 in the lower range of scenarios and to $390 billion in 2040 in the higher range of scenarios, a CAGR of 15 to 35 percent. The middle estimate for alternative proteins puts the market at $130 billion in 2040. This wide range reflects the market's nascency and the uncertainty that stems from its dependence on scientific breakthroughs and major consumer dietary shifts. The estimates include fermented and cell-based alternative proteins but exclude plant-based products.

Three key factors are likely to determine the segment's growth. First, the market's trajectory is shaped by the increasing share of protein in global diets, which correlates closely with economic development and per capita GDP growth. According to the OECD and the Food and Agriculture Organization of the United Nations, meat consumption could increase 2 percent by 2033, driven primarily by population and income growth in middle-income countries, and 79 percent of total growth could come from middle-income countries, even as consumption in most high-income countries is expected to stagnate. The increasing demand for meat, particularly in developing countries, could create an opportunity for alternative proteins to play an important role in meeting global meat and protein needs.

Second, alternative proteins could significantly increase their share of total protein consumption in coming decades. For now, they constitute just 0.8 percent of the overall protein market, though that share could grow to between 1.0 and 9.0 percent by 2040. However, reaching the higher range of these estimates would depend largely on overcoming formidable barriers such as consumer acceptance and taste and texture preferences. The public's acceptance and widespread use of alternative proteins could hinge on R&D efforts focused on making products that match or surpass the taste and satisfaction provided by traditional protein sources. As these challenges are addressed, alternative proteins would be poised to play a more substantial role in future dietary choices and global food systems.

Third, price stands out as the most significant barrier to widespread adoption. A 2022 paper found that in 2013, the cost of producing cultured meat[297] in the lab was $2.3 million per kilogram, though with technological breakthroughs, that cost could be significantly reduced to $63 per kilogram, still about ten times as expensive as the wholesale price of animal meat.[298] High production costs are a function of both operating costs (for example, growth factors) and inadequate yields (meat produced per volume of bioreactor), both areas of active research and continued progress. In tandem with further efficiencies and learning from operating at large scale, advances in these areas can further drive down unit costs considerably. Crucially, the trajectory of regulatory frameworks, such as the promotion of carbon pricing and land conservation measures, will heavily influence the comparative price dynamics of alternative and conventional proteins. These regulations could improve or hinder the cost competitiveness of alternative proteins, shaping their market viability and adoption rates in the years to come.

Biomaterials and biochemicals. Biomaterials and biochemicals are substances or materials produced by microorganisms or created through biological processes such as fermentation and biocatalysis. These include biopolymers as well as enzymes for use as feed additives or required for industrial processes. The end-use cases include chemical processing and materials production, household products, agriculture, food, and nutrition. For example, corporate players and start-ups have developed and commercialized biotechnology-based additives for use in food, animal feed, and microbial products to improve yield or nutrition. The biomaterials and biochemicals market's revenues

grow from $41 billion in 2022 to $70 billion in 2040 in our lower range of scenarios and to $100 billion in 2040 in our higher range of scenarios, a CAGR of 3 to 5 percent. In the higher range, this market grows and biomaterial or biochemical substitutes would increase their share relative to traditional materials. In the lower range, the market grows steadily but biomaterial and biochemical penetration would remain the same.

The market trajectory of the biomaterials industry could depend on two main factors: whether customers will be willing to pay a higher price for substitutes over traditional (synthetic) materials, and the extent to which the properties of novel biosubstitutes will be comparable or superior to traditional materials.

First, biomaterials and biochemicals are often more expensive than traditional materials, which can affect their market penetration. For instance, biodegradable plastics derived from renewable biomass sources such as cornstarch, sugarcane, and potato starch are designed to be broken down using standard procedures. By contrast, traditional plastics are nondegradable, durable, and persistent, and accumulate in the environment. However, biomaterial substitutes often cost approximately 20 to 30 percent more because of the higher cost of raw materials and complex production processes.

Second, biomaterials often face challenges due to inferior material properties that can hinder their adoption rate. Biodegradable plastics, for instance, are engineered for functions similar to those performed by products made from polyethylene, polypropylene, and polyvinyl chloride, such as plastic bags, containers, and pipes, but the biodegradable materials may be less durable or have other performance limitations. For example, starch-based biodegradable plastics are known to have poor mechanical properties, hydrophilicity, and low thermal stability, while polylactic acid bioplastics can exhibit brittleness and elevated moisture uptake.[299] These factors influence market dynamics, shaping both consumer preferences and industry innovation aimed at enhancing the viability and competitiveness of biomaterial solutions. Moreover, according to a McKinsey report, "not all biomaterials are created equally," and the end-user adoption rate of biomaterials will depend upon the ability of companies to understand the technical differentiation of different products and select the appropriate end market.[300]

Consumer products and services. In our estimates, this market's revenues grow from $36 billion in 2022 to $71 billion in 2040 in our lower range of scenarios and to $170 billion in 2040 in our higher range of scenarios, a CAGR of 4 to 9 percent.

The market could include a wide variety of goods and services created by industrial and consumer biotechnology: direct-to-consumer genetic testing; meals and vitamins based on people's genes; microbial skin-care products; gene therapy for cosmetic purposes, such as reversing hair loss; genetic tests and treatments for pets; and perhaps even genetically modified pets. Most of these do not exist yet, though some do; for example, 23andMe has offered consumers saliva-based genetic testing since the mid-2000s, and companies are launching subscription-based meal plans and dietary supplements tailored to customers' DNA and microbiomes.

The personalized nature of these innovative products and services and their potential to enhance individual well-being could fuel consumer interest in solutions tailored to genetic or physical profiles, dietary needs, and aesthetic preferences. For example, companies like Ancestry and 23andMe have capitalized on the growing demand for personalized healthcare by offering genetic analysis services that could aid the early detection of hereditary diseases. These factors will likely continue to drive future demand as customers increasingly seek tailored products that leverage technological advances to better meet their needs.

The market's revenues will depend significantly on whether companies can address current regulatory concerns about the collection of genetic information and create enticing value

propositions at reasonable prices. Revenues will also depend on whether companies can accept the long development times that frequently characterize these kinds of products and services. For example, businesses are already planning ways to monetize the genetic data collected by some of these technologies—an endeavor that could prompt privacy and regulatory concerns.

Four key enablers could accelerate growth in all four segments. First, advanced computing, data analytics, machine learning, AI, and biological engineering are accelerating R&D. For example, in 2023, Google DeepMind introduced GNoME, a new deep learning tool that can help discover new materials by predicting their stability. The AI tool was used to find 380,000 stable materials that could hold promise for future technologies.[301] Second, efficient commercialization to scale from lab to mass production is vital. Third, public and government investments, such as the US government's $2 billion in funding for biotechnology and biomanufacturing, could further support these efforts. Fourth, continued corporate commitments to and consumer interest in sustainability will set the pace of growth in the industrial and consumer biotech market. The market for biomaterials is likely to expand more rapidly in scenarios where sustainability commitments are emphasized. Conversely, market growth could be slower if these commitments wane, as price and convenience could outweigh environmental considerations for both consumers and businesses.

Dynamism

The industrial and consumer biotechnology industry is young, and thus likely to show high dynamism, as companies seek to develop viable technologies and find sustainable business models for revenues and profits. For now, the industry is fragmented and contains small, science-focused start-ups; incumbents in industries that make products that biotechnological advances would replace; and cross-sector platform companies that provide product-development services such as R&D, commercialization, and manufacturing. However, it is possible that just a few larger companies will emerge as the industry matures. An early-mover advantage would give these larger players the scale and financial reserves to increase their investments in R&D and bring new products to market faster. Larger companies with early successes would also have the cash and reputation to find novel biotechnologies by acquiring smaller upstarts, as occurred in the pharmaceutical industry. The need for high R&D investment could create barriers to market entry and cause a few large players to emerge over time.

Larger companies could acquire agricultural biotechnology start-ups to bring new innovations to market at scale. For example, Cardea Bio led the research initiative to develop a biocompatible semiconductor that could translate real-time multiomics signals into digital information. Cardea was acquired by Paragraf, an integrated device manufacturer in the semiconductor industry, to accelerate the mass production of these devices.

However, the direction and pace of scientific advancement are not always linear, and higher R&D budgets are no guarantee of bringing a successful product to market. The number of larger companies might also be limited if smaller upstarts continue to make breakthroughs that can be brought to market relatively easily. In addition, platform players that provide biotech services such as strain engineering, fermentation optimization, and product development could support a more fragmented market by providing pathways for product development and commercialization, allowing smaller players to access the resources required to scale their innovations.

Swing factors

— As new biomaterials are developed with improved performance characteristics (for example, environmental impact, yield, and strength), how fast can they be commercialized at scale?

— Can new biotechnology alternatives achieve the consumer demand or comfort to become competitive with conventional products such as meat or plastics?

— As biotechnology has grown in scale and importance, consumers in many countries have expressed concerns such as whether genetic testing companies can keep their genetic data secure and whether companies should have the right to profit from customers' genetic results. How will public confidence evolve?

Contributing author:
Robin Riedel

16. Future air mobility

A variety of new future air mobility use cases—in transportation of people and goods and in surveillance—are emerging as advances in technology enable new types of aircraft and operations. The market segments in the industry include urban air mobility, regional air mobility, last-mile delivery drones, and supersonic and hypersonic transportation. We focus on two of them: passenger urban air mobility and last-mile drone delivery. If their makers' ambitions come to pass, electric vertical takeoff and landing vehicles (eVTOLs) and delivery drones could become a common sight in many cities, turning skylines into scenes from science fiction.

The future air mobility industry is fueled by four major trends: the rapid advances of technologies such as batteries, autonomy, and digital engineering; the global focus on sustainability; the increasing prominence of shared mobility; and the need to create solutions to traffic congestion. Indicators suggest that the industry could become an arena by 2040. Annual disclosed funding for future air mobility grew from less than $600 million in 2017 to $5 billion in 2023, with cumulative disclosed investment of $22 billion. From 2013 to 2023, about $18 billion was invested in passenger eVTOL and last-mile delivery drone businesses.[302] Moreover, several eVTOLs (such as aircraft from Archer, Joby, Lilium, Volocopter, and others) are undergoing flight testing for certification, and companies have already started making last-mile deliveries by drone, including more than one million deliveries in 2023 for last-mile logistics, restaurants, groceries, and healthcare providers.[303]

Most passenger eVTOLs would typically carry two to six passengers and are generally designed for intracity trips (up to 50 kilometers) and urban or suburban trips (50 to 120 kilometers). Last-mile delivery drones are far smaller and typically carry packages lighter than 10 kilograms containing goods such as groceries, medicine, mail, and retail items. Both eVTOLs and delivery drones are powered by battery-electric power trains; the drones would mostly take off and land vertically.

Growth

The future air mobility industry's revenues are almost nonexistent today and could grow substantially in the coming years, with projections ranging from $75 billion by 2040 in the lower range of scenarios to $340 billion by 2040 in the higher range of scenarios.[304] The industry could see rapid growth through 2035 due to its nascency, but growth could moderate once the industry achieves some scale. However, even at scale, the industry would still represent only a small share of the larger transportation market; for example, in these estimates, passenger eVTOLs would account for the equivalent of less than 1 percent of all trips undertaken via ground transportation.[305]

We measure the industry's revenues as the amount the service operators would take in. We estimate that 20 to 35 percent of the total revenues of passenger eVTOL operators could be paid to manufacturers (with much of that paid to suppliers of components, such as batteries, airframes, and aircraft systems), and 10 to 40 percent would be allocated to suppliers of mobility platforms (including software for ticketing, scheduling, and navigation), licensing, financing, insurance, and air traffic management.

The growth of the industry will likely depend on three main factors: price, customers' preferences, and the rate of technological advancement in battery performance and autonomy.[306] However, two additional factors could limit that growth: regulation and the development of necessary infrastructure.

Price: For the industry to grow toward the higher end of our range of revenues, the price of an eVTOL trip or drone delivery would have to become competitive with that of other modes of transportation.

*Note: This section describes the potential growth and dynamism of the **future air mobility** arena. It should not be read as a comprehensive account of the industry. To learn more about future air mobility and associated industries, please refer to content from the McKinsey Center for Future Mobility.*

For example, the median price of a regular ride-hailing service in 2022 varied highly by location, from as low as $0.50 per kilometer in much of South and Central America to as high as $3.50 per kilometer in New York and $4.30 per kilometer in Bern, Switzerland.[307] Our estimates suggest that for eVTOLs, the price once the market reaches scale could be between $2.00 and $4.50 per passenger per kilometer, driven by a combination of component costs, operational costs like pilot salaries and maintenance, infrastructure costs, and the economics of round-trip traffic, charging, maintenance times, and peak-hour utilization.[308] This suggests that eVTOLs could offer a service that would be competitively priced compared with premium ground transportation, especially in areas where ground transportation is expensive. And even at a higher price, some customers might be willing to pay for passenger eVTOLs if they are more convenient or faster than the alternatives.

Last-mile delivery drones may also become cost competitive. Current unit delivery cost by drone is higher than delivery by van, especially if the van is carrying multiple packages. However, this is partly because in some jurisdictions, regulations permit a person to operate only one drone at a time within visual line of sight. But if an operator could oversee 20 drones beyond visual line of sight, drone delivery costs could become comparable to van delivery costs, according to our estimates. Completely automated drones could drive those costs down even further.[309] Minimizing drones' footprints (by optimizing their use of airspace or changing drone size) and maximizing throughput (by improving utilization) could also affect unit delivery cost by drone.

Customers' preferences: A McKinsey survey of about 5,000 respondents indicated that although meaningful numbers of customers would consider eVTOLs for commuting, running errands, business and leisure travel, or getting to the airport, many were concerned about aircraft safety and trip price.[310] The survey also found that time savings was by far the main reason most respondents gave for considering eVTOLs, suggesting that people in cities with severe traffic congestion or geographic obstacles might be more open to using them. Current users of limousine and ride-hailing services were also likelier to say they might use passenger eVTOLs.

Customer experience will help determine the extent to which eVTOLs are adopted. The aircraft might save time, but car travel also has advantages.[311] For example, taxis and ride-hailing services operate on demand, whereas some passenger eVTOL flights are expected to follow a schedule. In addition, most eVTOL passengers could still need to arrange ground transportation for the first and last mile of their journeys. Reliability might also be an issue, because aircraft require more maintenance and stricter safety protocols than cars, and their operations could be subject to weather cancellations.

The future of last-mile delivery drones also depends on how well they can meet a variety of customer needs and overcome the public's hesitation. On the one hand, drones could reach remote areas with poor roads and could circumvent traffic congestion in cities, satisfying customers' preference for delivery speed and convenience. According to a McKinsey survey, 56 percent of consumers would choose drone delivery if it was faster than traditional delivery and cost the same. On the other hand, McKinsey research also suggests that the safety of drone deliveries, the noise they produce, and the potential invasion of privacy are of concern to consumers.

Battery technology: While companies have already addressed many of the key technical challenges for eVTOL flight, batteries, in particular, pose a large challenge. Technical challenges remain in areas such as battery density (how much energy and thus range of flight a battery can supply per unit of weight), cycle life (lifespan before replacement), recharge time, and performance in cold weather, when batteries underperform. For example, enabling longer regional commutes via eVTOLs could require higher-density batteries.

Moreover, for eVTOL services to reach profitability, their batteries would have to be able to charge and discharge more quickly than electric car batteries and have longer lifetimes. Similarly, while current battery technology is able to support drone use cases involving flights up to 60 minutes,

last-mile delivery drones would benefit from further improvements in battery technology that enable longer flights. The good news is that battery technology is advancing rapidly (see the "Batteries" entry in this compendium). Growth in future air mobility will depend on the speed of technological advancement in battery technology and the cost at which batteries can be provided.

Regulation: For eVTOLs to scale up, regulations allowing and governing their deployment will be necessary. In 2023, the US Federal Aviation Administration (FAA) announced the steps needed to achieve a competitive, scaled-up air taxi market by 2028.[312] The European Union Aviation Safety Agency has been developing a set of conditions for the certification of new passenger eVTOLs.[313] Some companies, such as AutoFlight and EHang, have already received airworthiness certification in China.[314] But fully building out a mature eVTOL-specific regulatory environment may take time. Some eVTOLs could be operated autonomously one day, presenting a whole new set of regulatory considerations.

Regulatory standards for delivery drones are also starting to evolve. For instance, Australia has approved Wing for drone deliveries in North Canberra, and Logan and Swoop Aero for drone deliveries within 60 kilometers of bases in Toowoomba and Goondiwindi.[315] Meituan has been approved in China and made more than 100,000 drone deliveries in Shenzhen in 2022.[316] In addition, SF Express received a license for delivery drones in January 2022 and has established more than 60 routes covering areas in Longgang, Nanshan, Luohu, Longhua, and Pingshan. In the United States, the FAA authorized operations beyond visual line of sight at seven test sites in September 2023 for UPS Flight Forward and Zipline. Since then, the number of companies with specific approvals has grown sharply and now includes Amazon, Wing, and DroneUp, among many other operators, though they are mostly operating at a small number of facilities and locations. Authorities in the European Union and the United Kingdom have also made progress.[317]

Infrastructure: In some cases, passenger eVTOLs could take off and land at existing regional airports or heliports. But larger-scale passenger operations would require dedicated boarding and loading facilities, where the eVTOLs would also be parked and serviced. More important, establishing physical infrastructure such as takeoff and landing spots along passengers' preferred routes will be crucial. As detailed in a McKinsey article, without a robust network of facilities, known as ports, "flying-vehicle transport could follow a pattern similar to that seen in today's helicopter market, where the number of potential destinations is limited."[318] These networks would require land and investment. In addition, existing facilities would need retrofitting to accommodate the charging infrastructure needed for eVTOLs. Investment in more extensive facilities could follow as the market takes root and demand grows. An urban network of facilities with 85 to 105 landing pads could cost between $230 million and $300 million to build and between $165 million and $195 million annually to operate. There are already some plans in North America and Europe to start developing such networks, and about 20 ports were under way in each region as of 2022.[319]

Delivery drones also require some specialized infrastructure. However, since it can be built with smaller footprints in areas outside dense urban centers and the facilities may need fewer or smaller landing pads, the challenges for building physical infrastructure aren't as limiting. At the same time, advancements in digital infrastructure, such as more sophisticated unmanned traffic management (UTM) systems, are key to realizing innovative drone delivery applications. Advancements in UTM technology that enable sophisticated drone tracking and coordination with air traffic control systems can help enable higher-altitude drone flights than are currently feasible.[320]

Dynamism

Because the industry is nascent, any growth would constitute a major share shift, increasing the likelihood that future air mobility would qualify as an arena. In the meantime, it is possible to glimpse the contours of the industry that could emerge.

While passenger eVTOLs are still in their infancy, the prospect of scaling them up could be attractive to new entrants, especially as the vehicles spread to new regions. Once the market reaches a certain size, economies of scale and customer acquisition would probably lead to consolidation of market share among leading players as providers drop out, much as we have seen in the ride-hailing industry, as players without significant capital backing exit the market.

It is unclear whether the most successful business model will be a vertically integrated one, in which eVTOLs are built and operated by the same company, or a more traditional supply chain, in which manufacturers build eVTOLs and sell them to operators. If vertically integrated companies manage to operate more efficiently and beat out smaller companies, the industry could favor fewer large players. But if the ability to operate in heterogeneous markets promotes a structure in which manufacturers sell eVTOLs to operators, the industry could instead become more fragmented, with a smaller set of manufacturers but a large set of local operators. Business models may also be unique to different regions and their regulatory and cost landscape, so a one-size-fits-all solution may not prevail globally.

Prospects for last-mile delivery drones are somewhat easier to observe in the short term because they are already operating commercially, unlike eVTOLs. Some companies are doing trials, and others are already scaling up operations to deliver medical supplies, retail purchases, and food. In the most common business model, drone manufacturers operate last-mile delivery services in partnership with retailers, medical organizations, or third-party logistics providers. For example, in March 2024, Wing and the food-delivery service DoorDash announced a pilot program in Virginia, following a 2022 pilot in Australia that has since grown to include more than 60 restaurants and other merchants.[321] Walmart has partnered with four drone delivery companies and established 36 stores as drone delivery hubs.[322] In addition, major retail and logistics companies are developing in-house drone delivery technology; Amazon Prime Air is an example.

In the long term, the drone-delivery market could have a small number of large players regionally or even globally, depending on the extent to which different regions require different operations. Business models may also evolve as the market matures and companies develop deep expertise and specialization. Since the hardware is likely to become commoditized, companies that can operate scaled-up networks cheaply, optimize logistics, and satisfy complex regulatory requirements could have an advantage. Scale will help delivery drone operators build these advantages, conferring a first-mover advantage and raising barriers to entry for new players.

Swing factors

- What steps might regulatory bodies (such as the FAA) take to enable the industry to operate at scale (for example, greater coordination with industry)?
- Can passenger eVTOL companies build a sustainable business model and achieve profitability, and what timeline would let them avoid remaining an expensive niche product?
- How will public acceptance of these innovations evolve and affect the market, especially when it comes to concerns about safety and noise? Would consumers be willing to pay a premium for future air mobility over other modes of transportation?

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Contributing authors:
Josh Sternberg,
Corina Curschellas

17. Drugs for obesity and related conditions

As the world grows more prosperous and people live longer, the already large impacts of chronic conditions such as cardiovascular disease, chronic obstructive pulmonary disease (COPD), cancer, diabetes, and brain diseases (including Alzheimer's disease) are expected to increase.[323] In the United States alone, the number of people over 50 with at least one chronic disease is projected to double from 72 million in 2020 to 143 million by 2050.[324] Globally, chronic diseases were causes or contributing factors in 75 percent of deaths in 2010 and 79 percent in 2020; by 2030, experts predict that they could be a factor in up to 84 percent of global mortality as more countries develop.[325]

A 2010 report from the Harvard School of Public Health and the World Economic Forum calculated the global economic burden of chronic diseases by using a cost-of-illness approach that includes both direct costs (those associated with diagnosis, treatment, and care) and indirect costs (such as lost income). The report found that cardiovascular disease, cancer, COPD, diabetes, and mental illness cost a combined $6.25 trillion globally in 2010. Using an alternative approach, the report found that the total lost economic output due to reduced labor and capital inputs caused by chronic disease mortality could cumulatively reach nearly $47 trillion from 2011 to 2030.[326] This economic impact is surely eclipsed only by the human cost of these diseases, which diminish both longevity and quality of life. These chronic conditions require a strong response aimed at "adding years to life and life to years."[327]

Obesity, the prevalence of which has skyrocketed over the past 20 years, has been directly linked to some of these chronic conditions, contributing to type 2 diabetes, heart disease, and some cancers.[328] A report by the World Obesity Federation calculates that the economic impact attributable to obesity alone was $2.0 trillion in 2020 and is projected to increase to $4.3 trillion by 2035.[329] A McKinsey Health Institute (MHI) analysis calculated the obesity-attributable disease burden measured in disability-adjusted life years (DALYs), which combine the years of life lost to premature mortality with years of life lost to states of less than full health or of disability.[330] One DALY represents the loss of the equivalent of one year of full health. According to MHI, 153 million global DALYs could be attributed to obesity in 2019. Many of these DALYs were due to obesity's connection to chronic conditions: 41 million from ischemic heart disease and 34 million from type 2 diabetes.[331]

The increasing prevalence of chronic diseases and obesity has led pharmaceutical companies into a race to develop more effective therapeutics that could bring about step changes in the treatment and management of these conditions.[332] One class of drugs, glucagon-like peptide-1 agonists (GLP-1s)—alone and in combination with gastric inhibitory polypeptides (GIPs)—appears to have the potential to greatly change the trajectory of obesity-related ailments. Starting in 2021, these drugs (originally developed to treat diabetes) began receiving approvals for treatment of obesity as well. The results have been striking: sales of GLP-1-based therapies such as Novo Nordisk's Ozempic reached $24 billion in 2022 alone, and the drugs have proved so popular that manufacturing supply has not kept up with demand.

The first wave of GLP-1s has already driven substantial growth for drugmakers. In the seven years since Novo Nordisk launched Ozempic as a drug for type 2 diabetes, the company's value has increased sevenfold to a market capitalization greater than $490 billion, and it has become the world's 12th-largest company and Europe's largest, surpassing giants such as LVMH.[333] Eli Lilly, with a market capitalization of more than $800 billion, recently became the world's most valuable pharmaceutical company, partly as a result of its GLP-1 agonist, Mounjaro/Zepbound.[334] In addition,

*Note: This section describes the potential growth and dynamism of the **drugs for obesity and related conditions** arena. It should not be read as a comprehensive account of the industry. To learn more about drugs for obesity and associated industries, please refer to content from the McKinsey Life Sciences Practice.*

the opportunities in the market have already drawn potential entrants: both Amgen and Pfizer had GLP-1 weight loss drugs in Phase II trials as of June 2023, while AstraZeneca and Roche concluded multibillion-dollar deals to secure weight loss drugs currently in development.[335]

Some studies suggest that these drugs could have broader uses, including the treatment of other chronic diseases. According to a 2019 study, GLP-1 agonists could help reduce inflammation, lower blood pressure, and produce neuroprotective effects, all of which are correlated with a reduced prevalence of Alzheimer's disease, hypertension, and fatty liver disease.[336]

The rapidly growing market for obesity-related drugs is poised to expand further as pharmaceutical companies race to develop new versions of the GLP-1 agonists. Moreover, GLP-1s are just one class of drugs that could improve outcomes related to obesity. As the pharmaceutical industry invests in medical solutions across the range of chronic diseases, the potential for more breakthroughs indicates that these therapies are likely to become an arena.

Growth

While nascent demand across the range of chronic diseases is high, we focus on the obesity drug industry—which has already seen a breakthrough—as a real-life example of what could happen with treatments for chronic diseases. We anticipate that growth in this industry and its rapid technological innovations may derive from consistent demand due to rising rates of obesity and other chronic ailments, the price sensitivity of pharmaceuticals, and rates of patients' adoption and treatment. We measure the industry's revenues as the total global sales of GLP-1s and other obesity drug therapies for patients who are diagnosed with obesity and are prescribed the drugs as part of their treatment. Some of these patients may use the drug in its injectable form, and others could eventually take an oral solid pill if companies are successful in developing one.

In our modeling, the market could grow from $24 billion in 2022 to $120 billion by 2040 in a lower range of scenarios and to $280 billion by 2040 in a higher range, a 9 to 15 percent CAGR.[337] This growth rate would imply a market size of $50 billion to $70 billion in 2030 assuming continuous growth from 2022 to 2030, though the market may grow faster until 2030 than it would from 2030 to 2040. Faster growth through 2030 seems possible, and projections from Goldman Sachs, JP Morgan, and others have estimated that the market could exceed $100 billion by 2030.[338]

The key driver of the range of market projections is the price of obesity drugs. While our analysis assumes that improved clinical outcomes, reduced manufacturing and production costs, increased competition, and the loss of exclusivity will drive down prices over time, the extent of the decrease, along with its associated volume impacts (the number of patients accessing obesity drugs), will determine the size of the market. This price sensitivity is due to the unique nature of the pharmaceuticals market, where prices are not solely the outcome of a supply and demand market equilibrium but are driven by a country-specific mix of intellectual property, healthcare regulatory and reimbursement policies, and local competitive dynamics.

The adoption by the public of new GLP-1-based drug therapies or other innovative formulations is fueled by the limitations of existing obesity and weight loss therapies. The new GLP-1 agonist-based drugs such as Ozempic—which seem to emulate the effects of hormones that make patients feel sated, though their exact mechanism is still being researched—have transformed the expectations of weight loss efficacy, with some medications promising reductions in body weight of more than 15 percent.[339] That is nearly double the efficacy of previous GLP-1 weight loss drugs, such as Novo Nordisk's liraglutide-based Saxenda, which was associated with less than 10 percent weight loss.

Rising rates of obesity point to a growing global need for effective treatments. Obesity already affects about 16 percent of the global adult population (defined as those age 20 and over) and is projected in the World Obesity Federation's 2023 Atlas to affect about 25 percent of adults worldwide by

2035.[340] To calculate the 2040 obese population, we used the obesity rates in the World Obesity Atlas projected for 2035 along with the medium fertility variant from the UN's World Population Prospects for the total adult population by region.[341] This showed that more than 1.5 billion adults could be affected by obesity in 2040, in an estimated global population of 9.2 billion. This scenario is segmented by regional estimates of the prevalence of obesity, from North America and Latin America, where nearly 50 percent of the population could experience obesity in 2040, to Asia and Oceania, where only 13 percent and 17 percent of the population, respectively, would experience the disease in 2040.

Our scenarios for possible market sizes in 2040 consider the following factors: the rising prevalence of obesity globally, the annual cost of drugs per patient, and the subsequent obesity diagnosis and drug treatment rates. To account for price elasticities, our approach explores two price scenarios and makes some assumptions about the volume implications for each. We start with price, which could be the biggest factor determining how widespread these drugs become because there is so much latent global demand for obesity treatments. The number of patients with access to the drugs could expand significantly if the annual cost per patient is relatively low. Other interdependent factors could affect this market's shape in 2040. The trajectory of research into new formulations—for example, the development of an effective oral solid obesity pill rather than the current injectables—and these treatments' effects on related conditions like heart disease, along with regulatory outcomes and competitive moves by players in the market, are impossible to predict but will play a large role in shaping the future of these drugs globally.

However, we can imagine a scenario in which improved clinical outcomes, reduced manufacturing and production costs, increased competition, and the loss of exclusivity drive down the price of obesity drugs over time, in which case the addressable market would go from niche to truly mainstream. Wegovy, the leading GLP-1 agonist prescribed for weight loss, is currently listed at about $16,000 a year in the United States, though the net price received by the manufacturer after discounts and coupons is about $8,400, according to a 2023 study by the American Enterprise Institute.[342] The cost of these medications could decline as a result of improvements to production and innovative formulations (think oral solid pills).

As many pharmaceutical companies research and release new obesity drugs, competition in the industry is likely to increase, which would result in lower prices. The Centers for Medicare and Medicaid Services may choose Ozempic (which is not approved for weight loss) for price negotiations under the Inflation Reduction Act.[343] Patent protection for the branded injectable GLP-1 agonist compound used in Wegovy and Ozempic is set to end in the early 2030s, when generic producers will step into the market, increasing downward pressure on prices. How low the price could fall may depend on how much producers can lower their production costs, as well as the number of new entrants and the intensity of competition in the market. Outside of price and its impacts on volume, other factors also affect diagnosis and treatment rates, including but not limited to impediments to physicians prescribing the drugs, limited coverage for obesity therapies, and concerns about the costs and side effects of long-term obesity treatment.

In the higher range of scenarios we model, prices drop radically, to an average of $500 a year per patient worldwide, across all available obesity medications. We chose $500 as a comparable price to other widely used drugs treating chronic conditions, such as statins,[344] and slightly less than AARP's estimate of the average annual cost of therapy for a widely used generic drug at $679 per year.[345] In this scenario, it is likely that pharmaceutical companies would succeed in further reducing the costs of production and that there would be a diverse market with branded and generic GLP-1s competing for patient access. In this scenario, we assume diagnosis and treatment rates similar to those for heart disease patients who take statins and similar medications to manage blood pressure. We model a scenario in which approximately 75 percent of North Americans with obesity would take

the drugs, along with 50 percent of Europeans and 20 to 50 percent of populations in Asia, Africa, Latin America, and the Middle East, leading to a total of about 550 million obese adults being treated globally (just under 40 percent of the global adult obese population).

In this scenario, the resulting market size would be $280 billion in 2040, with many patients taking the drugs at a lower cost. A number of other assumptions would also need to be true to achieve this market size: manufacturers would need to scale up massively to produce doses for 550 million patients a year globally, and they would need to remove the current production bottleneck in the fill-finish production step. In addition, competition would have to be sufficiently intense to bring down the price from today's level, healthcare payers worldwide would have to recognize the drugs' benefits and offer coverage, side effects would have to be mild enough to promote widespread adherence, and there would have to be widespread recognition from patients and doctors that obesity is a treatable condition.

The lower range of scenarios assumes that the blended price of obesity therapies (blended across all branded and generic options) in the United States in 2040 would fall, but not as low as $500 a year per patient. Instead, the scenario assumes a price of $2,500 a year per patient, similar to the average annual cost of current diabetes medications, while each patient in most other regions would pay about $900 per year for the same treatment.[346] This also assumes that 57 percent of the global obese population is diagnosed[347] and that of those diagnosed, about 20 percent of obese patients in North America and Europe would take these drugs, while about 10 percent of those diagnosed would take them in the rest of the world.[348]

Altogether, these numbers point to a total global patient population of about 100 million obese adults (just under 7 percent of the global adult obese population) using the drugs. In this scenario, the market size for obesity drugs in 2040 could be $120 billion, growing at a 9 percent CAGR from today. The higher price and lower volume assumptions in this scenario could be a result of some combination of the following four contributing factors, among others:

— Continued challenges prolong current production bottlenecks.

— There is no widely available small-molecule oral pill.

— Some patients end treatment as a result of unpleasant side effects and other causes.

— Healthcare payers are willing to offer some coverage, but not at the same rate as in the lower price scenario.

While $120 billion to $280 billion in revenues would require sustained growth and massive increases in patient access, these drugs could prove a relatively cost-effective intervention in the context of global pharmaceutical spending considering their potential healthcare impact. Global spending on drugs reached $1.48 trillion in 2022 and is forecast to increase 7 percent a year until 2028.[349] While we cannot know the exact trajectory of the drug market in the future, if this growth rate continues through 2040, $120 billion to $280 billion of obesity drugs would reflect less than 5 percent of global pharmaceutical spending, less than the relative market size of oncology drugs today (currently about 12 percent).

Dynamism

The introduction of new obesity drug therapies has already begun to shift market share toward the first movers in the space while simultaneously pushing incumbents in other pharma submarkets to develop their own obesity therapies. This new area of competition could reset the S-curve for obesity treatments and offer incentives to new players to enter the field.

The early commercial success of GLP-1s is triggering escalatory dynamics as pharma majors invest in R&D to develop the next generation of branded drugs. As with other drugs, GLP-1s require substantial up-front investment due to unpredictably long development and approval timelines. Given the likelihood of increased pricing pressures once generics are introduced, current players will likely be encouraged to develop new branded drug therapies with higher efficacy, fewer side effects, or less intrusive ingestion methods—for example, oral solids replacing injectables.

However, with more than six applications already filed for generic semaglutide, a large number of generics producers will likely emerge after Novo Nordisk loses exclusivity of its first-to-market compound by the early 2030s in major markets such as the United States and Europe. That milestone would drive the market toward relative fragmentation. While pharmaceutical companies may try to develop second- or third-generation branded obesity treatments, the drugs would have to show superior performance to be preferable to low-cost generics with clinical profiles similar to those of existing options. And even if these new second-generation drugs succeed in the market, the introduction of generics based on the first-generation drugs could exert considerable downward pricing pressure on the market.

The discovery of step-change treatments for other chronic illnesses would likely set off a similar escalation of R&D investment, with major pharmaceutical companies entering the arena, followed by fragmentation with the entry of generics producers. For example, 1,600 treatments and vaccines for cancer were in development in 2023, a more than twofold increase from 2014.[350] As the global burden of chronic diseases becomes increasingly significant, the potential impact of pharmaceutical solutions increases, too.

Swing factors

- Researchers are investigating whether GLP-1-based therapies can be used to treat other chronic diseases. If that research proves successful, how much more widespread could GLP-1 treatments become?
- As the prevalence of obesity increases globally, what impact might the global recognition of obesity as a disease by medical stakeholders (governments, public health agencies, payers, and R&D companies) have on the market in price and volume?
- The convenience and tolerability of the drugs likely will have a large impact on their uptake. Can research identify options for obesity treatments that are more convenient and have fewer side effects?
- If considering the broader set of chronic conditions that make up a large share of the healthcare burden, what could be the impact of developing similarly efficacious therapies for other chronic conditions?

Contributing author:
Chad Cramer

18. Nuclear fission power plants

The nuclear fission power plant industry dates to the 1950s. It encompasses the construction of power plants that leverage nuclear fission to produce energy, including traditional large-scale reactors (LSRs) as well as small modular reactors (SMRs) and microreactors, which are more recent technological advancements. Nuclear fission works by splitting an atom into two smaller atoms, releasing energy in the process. Fuel sources for nuclear fission today include uranium-235, plutonium-239, and thorium-232 isotopes. Nuclear power can generate one million times more energy than fossil fuels per mass. Today, nuclear fission reactors are a leading source of electricity generated without emissions of greenhouse gases.[351]

As the demand for energy rises with economic development, electricity generation is projected to roughly double from 2022 to 2040.[352] In addition, with efforts to decarbonize, the energy mix could significantly change as energy users switch to low-emissions sources from emissions-intensive sources such as coal and other fossil fuels. Nuclear power has high potential to fill these energy needs. It is already able to provide stable baseload electricity to the grid, unlike solar, which cannot produce energy at night, and wind, whose generation depends on variable weather patterns. Furthermore, the rapid expansion of solar and wind power could slow down because of factors such as the scarcity of land for solar and wind farms, the time that it takes to build the necessary transmission infrastructure, and the difficulty of scaling up electricity-storage capacity quickly enough.

Both private investors and governments in many markets are driving momentum in support of the expansion of nuclear generation. Investors are showing interest, even though the industry has high capital costs and investments take a long time to produce returns. Global venture investment funding of nuclear companies shot up from $60 million in 2018 to $390 million in 2022. Companies are also facing higher electricity demand caused by the increasing prevalence of artificial intelligence (AI) and supercomputing, alongside sustainability goals. Nuclear power offers a potential solution to meet these needs. For example, Microsoft is considering nuclear energy to power its AI data center operations.[353]

Several countries are starting new nuclear programs or expanding existing ones. The US Department of Energy has awarded about $3 billion to license, build, and demonstrate two next-generation plants, and the Inflation Reduction Act provides either an investment tax credit of up to 50 percent or a production tax credit of up to $36 per MWh for the first ten years of a new plant's operation. In 2022, the United Kingdom announced a $150 million fund to support new nuclear projects.[354] South Korea plans to increase the share of nuclear power in the country's energy mix to 30 percent or more by 2030.[355] In Finland, after the Olkiluouto 3 nuclear plant went into operation, the contribution of nuclear power to total electricity generation increased from 33 percent in 2021 to more than 40 percent in 2023.[356] Adding to this momentum, 25 countries collectively made commitments at the COP28 climate summit in 2023 to triple global nuclear energy capacity by 2050.[357]

*Note: This section describes the potential growth and dynamism of the **nuclear fission power plants** arena. It should not be read as a comprehensive account of the industry. To learn more about nuclear fission power plants, please refer to content from the McKinsey Global Energy & Materials Practice.*

Growth

Nuclear fission's growth may depend on decreasing the capital expenditures and time needed to build large reactors and SMRs as technology advances. Growth could also depend on the decarbonization paths followed by countries, which will each require varying amounts of the emissions-free "firm" energy production that nuclear power can provide.[358] The industry's revenues are projected to grow from $18 billion in 2022 to $65 billion by 2040 in a lower-range scenario and

to $150 billion by 2040 in a higher-range scenario, a 7 to 13 percent CAGR. A further breakthrough scenario could be possible if the cost of building nuclear drops significantly, leading to a market size of $400 billion in 2040, a 19 percent CAGR from 2022. These figures include revenues for the builders of nuclear fission power plants and do not include the cost of operations. The revenue estimates factor in existing operational capacity net of suspended and permanently shut-down facilities, capacity under construction, and countries' commitments to achieving net-zero emissions by 2050.

In the overall energy system, global electricity generation in 2022 was 27,000 TWh. Ten percent of that output was from nuclear sources, about 30 percent came from other lower-emissions sources, such as solar and wind, and the remaining 60 percent was from higher-emissions sources, such as coal and natural gas. In our estimates, nuclear power could generate between 8 and 19 percent of global electricity by 2040.[359] Under a breakthrough scenario we modeled in which capital expenditure per megawatt significantly drops, nuclear power could generate up to 43 percent of global electricity. Historical precedent also suggests that nuclear power could play a larger role in the energy mix than the 10 percent it provides today. Nuclear power underwent a construction boom from the 1970s to the early 1990s, when its share of total power generation globally increased from 2 to 18 percent.[360]

The contribution of nuclear power to the energy mix depends on three factors: building costs, whether solar and wind technologies become uninterrupted based on advances in storage and transmission, and the decarbonization scenario. First, capital expenditure for plant construction is a main driver of energy cost for nuclear power. Historically, the price ranged from a lower end of $2 million to $3 million per megawatt—for the P4 reactors built in France in 1984 and the APR-1400 reactor built in South Korea in 2010—to a higher end of $5 million to $13 million per megawatt for reactors built in the United States.[361]

As more countries build nuclear power plants and the global market grows, learning-curve efficiencies could push capital expenditure lower for large reactors, SMRs, and microreactors. For example, the Barakah nuclear plant in the United Arab Emirates achieved a 32 percent reduction in cost with each doubling of deployment volume.[362] Additional factors specific to LSRs, SMRs, and microreactors also apply. For example, SMRs and microreactors that can be assembled in factories from prefabricated components benefit from being constructed out of small, repeatable, and standardized components at scale, lowering production costs. Furthermore, SMR and microreactor construction involves repeating many smaller construction projects rather than managing one much larger project, enabling quicker learning iterations. The adoption and standardization of SMR and microreactor technology could also reduce costs, affecting the number of nuclear power plants that would be built. In the case of LSRs, improved economies of scale might drive long-term cost-effectiveness.

Second, the amount of firm power[363] required by a lower-emissions grid is an important factor. A less carbon-intensive grid that relies more heavily on renewables would also need a baseline of firm power to balance out energy demand and ensure reliable service. Currently, nuclear technology and hydropower are the only proven options for providing emissions-free firm energy production. Looking ahead, advancements in long-duration storage for solar and wind, geothermal energy, and carbon capture of emissions from fossil fuel power sources like natural gas could offer potential alternatives for supplying emissions-free firm power. Technology advancements in these sources will affect their cost, performance, and public acceptance compared with nuclear power, and thus affect the future energy mix.

Finally, the decarbonization path that countries choose significantly affects electricity demand, generation levels, and the energy mix because decarbonization involves the electrification of major energy use categories such as industrial processes, transportation, and heating and cooling. Under current policies, which may not be sufficient to achieve net zero, electricity generation is projected to

Exhibit

The number of new nuclear power plants depends on their cost relative to the cost of other sources of energy and decarbonization scenarios.

Nuclear energy market size, $ billion

	Lower growth	Higher growth	Breakthrough
Capital expenditure/MW, $ million	6–8	4–6	Up to 4
Decarbonization scenario	Countries maintain some of their momentum toward decarbonization, and/or other sources of firm clean power become widely used.	Countries maintain stronger momentum toward decarbonization, and nuclear becomes a major source of firm clean power.	Countries maintain stronger momentum toward decarbonization, and other clean power sources are not scaled up as planned.
Incremental annual capacity, GW	10	30	100
Potential number of reactors added annually	Up to 8 large or 31 small	Up to 26 large or 100 small	Up to 83 large or 330 small

Source: McKinsey Energy Insights *Global Energy Perspective 2022*; McKinsey Power Model; Net Zero country commitments, IAEA PRIS; McKinsey Global Institute analysis

McKinsey & Company

reach 50,000 TWH by 2040. In a scenario with more targeted policies and increased commitments, including from new adopters of nuclear power, electricity generation could reach 59,000 TWh.[364]

Higher-range and lower-range scenarios incorporating different assumptions for the three factors above yielded the market size and rationales illustrated in the exhibit above.

In the lower-growth scenario, industry revenues would expand from $18 billion in 2022 to $65 billion in 2040 at a CAGR of 8 percent. The capital expenditure per megawatt underlying this range falls at the higher end of estimates, between $6 million and $8 million. Under the scenario, 10 GW of capacity is constructed annually. This pace of construction assumes a mix of the following assumptions: that all nuclear plants already under construction or planned to be built by 2040 will be completed, that countries will maintain a similar pace of construction, and that countries follow through on some or all of their commitments to net zero.

This scenario also involves building up to eight large reactors or 31 small reactors annually, bringing nuclear capacity to 550 GW or 5,000 TWh by 2040. In that case, nuclear power could generate between 8 and 11 percent of global electricity, depending on the total energy produced under different decarbonization scenarios, similar to the 10 percent share it generates today.[365]

In the higher-growth scenario, industry revenues would expand from $18 billion in 2022 to $150 billion in 2040 at a CAGR of 13 percent. The capital expenditure per megawatt in this scenario is below the figure for the lower-growth scenario and falls between $4 million and $6 million. This scenario assumes that 30 GW of capacity is constructed annually. Growth hinges on favorable developments of the three factors mentioned earlier: the adoption of newer technologies such as SMRs to reduce costs and enhance safety, increased reliance on nuclear power as a substantial source of firm power compared with alternatives, and more ambitious decarbonization goals through support from both the public and governments.

Moreover, this scenario relies on sustained commitment from countries deeply engaged in nuclear power, particularly China, which plans to build 150 new nuclear reactors by 2035. It has 27 under construction, far exceeding Russia, the second-largest builder, which currently has only four reactors under construction.[366] The scenario also anticipates increased adoption of nuclear power by countries with minimal current capacity. It involves building as many as 26 large reactors or 100 small reactors annually, bringing nuclear capacity to 940 GW or 8,000 TWh by 2040. If those conditions are met, nuclear power could generate between 14 and 19 percent of global electricity, depending on the total energy produced under different decarbonization scenarios.[367]

That scenario aligns with the historic peak of 30 GW added per year in the 1980s. By contrast, a breakthrough scenario could produce even faster growth. For example, capital expenditure per megawatt could decrease significantly, possibly to less than $4 million per megawatt and closer to the $2 million to $3 million per megawatt cost of South Korea's APR-1400 reactor, making nuclear power cost-effective compared with other energy sources. Other emissions-free energy sources could fall short in supplying and distributing enough electricity at the right time to meet demand. There could be continued momentum in achieving global commitments for decarbonization by 2050. Nuclear energy could take on a larger role in off-grid power, heat, desalination, and AI data centers.

Our breakthrough scenario could lead to a market size of $400 billion by 2040, and a 19 percent CAGR from 2022. This scenario entails the addition of 100 GW added per year and involves building as many as 83 large reactors or 330 small reactors per year, resulting in 2,200 GW of nuclear energy capacity or 19,000 TWh by 2040. In this scenario, nuclear power could generate between 33 and 43 percent of global electricity, depending on the total energy produced under different decarbonization scenarios. While this would represent a historically large share of the mix for nuclear power globally, the share in some countries, such as Finland, France, and Switzerland, already exceeds 30 percent.[368]

Other factors influencing the growth of nuclear power include readiness of the supply chain to secure fuel sources and meet stringent standards for multiple nuclear components, availability of labor for plant construction, complexities in construction that may cause delays, and the ability to deal with nuclear waste. The amount of waste generated through nuclear power generation is small, but it remains highly radioactive; the nuclear industry has so far been successful in managing this issue. Government support can also affect growth through regulations and subsidies. The current regulatory framework applies to large reactors. The higher range of scenarios assumes that these regulations are adjusted to enable SMR adoption. Governments have historically used public subsidies to pursue nuclear power.

Dynamism

The nuclear fission power plant industry has a few well-established players with large market shares, although new entrants are making inroads with new technologies. The high R&D spending required for the design and construction of nuclear reactors, along with strict regulatory and licensing requirements, favors large companies with big market shares, such as Hitachi, Westinghouse, and China's State Nuclear Power Technology Corporation. At the moment, there are about 120 owners and 90 operators of nuclear power plants globally. Although the market for reactors is international,

nuclear power players tend to build only in countries to which they have geopolitical ties. Those factors limit the extent to which market share could shift. However, there is potential for larger players to extend to developing economies, particularly countries without major nuclear-energy companies.

The lengthy development process of next-generation nuclear fission power plant technology might also favor existing companies with large R&D budgets. New technologies require a long R&D phase to build experimental "lab-scale" reactors that prove scientific feasibility. Then companies must demonstrate a small-scale proof-of-concept reactor with sufficient stability of design. After these rounds of testing, the companies need to build the full-scale reactor to validate performance before full commercial deployment.

Nonetheless, newer entrants are developing the technology and could further scale it or sell it to utility companies. For example, TerraPower raised $830 million in late-stage venture capital (VC) funding in 2022.[369] That was supplemented by more than $2 billion from the US Department of Energy to build a nuclear power plant near a retired coal facility in Wyoming.[370] In Sweden, LeadCold is developing a Gen IV microreactor and received $2 million in late-stage VC funding, with an additional $11 million from the Swedish Energy Agency. Both companies have plans for plant site deployment in the late 2020s or early 2030s. Companies that are able to successfully develop newer technologies with advantages such as lower production costs and enhanced safety will likely have a significant first-mover advantage in capturing market share and could collect higher returns as front-runners in commercializing the technology. However, larger legacy players are likely to retain significant market presence given their scale, existing development contracts, and experience with government funding.

Swing factors

— How will global energy demand shift in the future as a result of policies related to emissions and other factors?

— How might technological advancements such as long-duration storage for solar and wind, geothermal energy, and carbon capture of fossil fuel power sources such as natural gas affect firm power supply and the uptake of nuclear power?

— How fast might companies accelerate learning-curve efficiencies in nuclear reactor construction to reduce capital expenditure for nuclear plants, and how sensitive would demand be to such price shifts?

— How much will governments support R&D and construction for nuclear power compared with other renewable energy sources? How will this backing vary across countries based on broader industrial policy? How might public perceptions about the safety of nuclear power evolve and affect public and government support for nuclear power?

— How active will large-scale off-takers—such as data-center hyperscalers and high process-heat demand manufacturers, for example—become in the funding, construction, and potential ownership of new nuclear power plants?

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Endnotes

Chapter 1

1 In this report we use the word "markets" and phrases including the word "market," such as "market segment" and "market niche." We may also show various calculations of "market shares." In doing so, we are referring to various groups of products sold globally or in a particular region that we think are useful to consider together. We do not intend to use the word "market" in any formal or legal sense.

2 Some industry classifications, such as software or telecommunications, map one-to-one to potential arenas. However, competitive battles happened either within or across more established industry classifications, so they can sometimes be averaged out (for example, EVs within the automotive sector). Moreover, more than 300 companies operate in multiple industries (such as Amazon in e-commerce and cloud) but tend to be placed in a single industry index. To address this, we created a segmentation of 57 distinct industries and categorized the world's top 3,000 companies from 2005 to 2020 within these segments. This approach involved splitting the revenues of 300 very large multi-industry companies into their respective segments.

3 These numbers cover only the e-commerce component of Amazon's valuation.

4 LG closed its smartphone business in 2021.

5 We conducted the Exhibit 5 analysis for 2005–19 to isolate the impact of the COVID-19 pandemic on economic profit. We also conducted the analysis for 2005–20, and the results are similar, with all arenas improving their ranking over the time period.

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7 Only data from the US National Center for Science and Engineering Statistics was used given the inconsistency in data quality of publicly reported R&D spend across our sample.

8 National Center for Science and Engineering Statistics and Census Bureau, Business Enterprise Research and Development Survey, 2020; McKinsey Global Institute analysis.

9 "Semiconductor design and manufacturing: Achieving leading-edge capabilities," McKinsey, August 2020.

10 *Research and development in the pharmaceutical industry*, Congressional Budget Office, April 2021.

11 As noted, we started from a list of the world's 3,000 largest companies. In this case, of the 29 companies we identified in the consumer internet industry, 16 either did not exist or did not report any market cap in 2005.

12 Because many companies fit into multiple arenas, the market caps used in our model are weighted to reflect the splitting of market cap across multiple business units. However, when calculating the top 10, the full market cap of the company was used, for example, $2.3 trillion for Apple's 2020 market cap, though $1.8 trillion of that was classified as in consumer electronics and $511 billion in hardware. See the techincal appendix for more detail on our weighting methodology.

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Chapter 2

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18 Kasper Karlsson, "Understanding the semiconductor value chain," Quartr, March 21, 2024.

19 See "Arenas are where investment and innovation happen" in chapter 1.

20 GDP growth annual (annual %), World Bank, accessed July 2, 2024.

21 The distinction between these two categories is not rigid as in both cases new products and services are displacing old ones, but it is a qualitatively different shift in the latter case.

22 This highlights the fact that the potion is not definitional for an arena but rather a falsifiable theory about what creates arenas, supported by evidence in almost every case, but to varying degrees.

23 "Siemens driving digital transformation with $10 billion investment in US software companies since 2007," Siemens, March 27, 2017.

24 Sunil Gupta, "Lessons from Amazon's early growth strategy," *Harvard Business Review*, April 24, 2024.

25 Data from PitchBook Inc. Analysis was not reviewed by PitchBook analysts.

26 Cody Slingerland, "101+ cloud computing statistics that will blow your mind (updated 2024)," CloudZero, December 2023.

Chapter 3

27 We use after-tax profit margins to refer to net operating profit less adjusted taxes (NOPLAT). The margins we considered were based on observed NOPLAT margins in industries most similar to our potential future arenas. In some instances, the benchmarks are clear, as in software, e-commerce, and pharmaceuticals (for the drugs for obesity and related conditions arena). In other instances, we considered a wide range of industries given the nascency of the potential future arenas. For example, modular construction took into account the construction engineering, building materials, and software industries, as well as NOPLAT margins of existing modular construction players.

28 McKinsey analysis incorporating data from Statista.

29 The analysis is limited to the sample of more than 3,000 companies we considered, of which more than 600 were tagged as belonging to arenas.

30 McKinsey analysis incorporating data from PitchBook Inc.; analysis not reviewed by PitchBook analysts. We mapped and tallied PitchBook's industry and vertical classifications that are closely attributable to arenas. Minor double counting of transactions may have resulted in instances where a deal is attributable to multiple arenas, such as e-commerce and AI software.

31 *Connecting for inclusion: Broadband access for all*, World Bank, accessed July 8, 2024.

32 We recognize that in some cases boundaries are blurred, especially due to the interconnected nature of different arenas and technologies such as AI.

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34 "Projecting the global value of cloud: $3 trillion is up for grabs for companies that go beyond adoption," McKinsey, November 2022.

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41 Ibid; Space IQ: Space Investment Quarterly, Q1 2023.

42 *The role of cybersecurity and data security in the digital economy*, UN Capital Development Fund, June 2022.

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60 "AR & VR—worldwide," Statista, accessed April 25, 2024.

61 "Global cryptocurrency market cap charts," CoinGecko, accessed July 6, 2024.

62 *Web3 developer report (Q3 2022)*, Alchemy Insights, October 2022.

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67 *The hard stuff: Navigating the physical realities of the energy transition*, McKinsey Global Institute, August 2024.

Arenas of tomorrow compendium

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Technical appendix

Chapter 1

Data set

The companies we analyzed were selected from more than 20,000 companies tracked in the McKinsey Value Intelligence database, applying the following filters:

— *Data quality:* Data at least included detailed reporting of income statement and balance sheet.

— *Parent companies only:* No double counting of subsidiaries.

— *Minimum market cap:* $3.5 billion in 2005 or $5 billion in 2020.

We augmented this initial database to account for IPOs and other M&A activities from 2005 to 2020, based on Capital IQ data. Seventy private companies with at least $5 billion in valuation as of 2020 were also included, along with their 2005 data.

For companies with missing market cap values for 2005, we looked at their 2020 market-cap-to-revenue multiples and applied this multiple to the companies' 2005 revenues to approximate 2005 market caps. All market cap numbers were measured at the end of the relevant calendar year.

This data set yielded 2,970 unique companies. Those that operated in several industries were split into multiple discrete entries. For example, Microsoft was split into four entries: cloud services, consumer electronics, consumer internet, and software. Amazon was split into two: cloud services and e-commerce. Publicly available data such as annual reports and press releases was used to calculate how to split these companies. This yielded a subset of 150 companies. We used the revenue split of individual business segments as the baseline to calculate the market cap split adjusted by the industry's multiple.

To illustrate our process with a hypothetical example, Theta Company has operations in both consumer electronics and cloud services. In this scenario, the consumer electronics segment generates $8,000 of revenue, and the hypothetical assumes that the industry has an average market-cap-to-revenue multiple of two. In cloud services, Theta has $2,000 in revenues, and the hypothetical assumes that the industry has an average market-cap-to-revenue multiple of eight. By multiplying the revenues and multiples, we find that Theta's market cap split between consumer electronics and cloud services is 50 percent each. We can then multiply Theta's market cap for the year by 50 percent to produce its market cap for each industry. For this model, each company-industry combination was treated as a unique data point. The final count of data points was 3,135.

The data set encompassed 57 different industries. Twelve of these were the current-era arenas we identified. These 57 industries were defined by starting with the McKinsey Value Intelligence data set, which as of 2023 contains 29 level two subindustries defined by McKinsey Industry Classification (MIC). These MIC subindustries differ from the standard Global Industrial Classifications (GIC) system by having three levels of granularity (13 level one industries, 29 level two subindustries, and 124 level three subindustries) compared with GIC's four levels (11 sectors, 25 industry groups, 74 industries, and 163 subindustries). Some of these MIC industries were then split into more granular industry definitions, depending on the company. These definitions were used in our final data set. For example, the MIC industry definition would have classified Tesla as belonging to the automotive and assembly industry. In our data set, companies in the automotive and assembly industry were classified as automotives, electric vehicles, or industrial equipment. As a result, Tesla was mapped

into electric vehicles instead of into a broader automotive and assembly industry. Some companies may have had a different MIC level two classification but were folded into the same industry group (for example, United Airlines was in the MIC level two air and travel classification, while Aéroports de Paris was in MIC level two transport and infrastructure, but they both are mapped to our air services industry). We conducted this kind of reclassification in six cases: consumer durables, air services, healthcare, consumer internet, freight and logistics, and information-enabled business services.

Exhibit A1 sets out the reclassification of companies from their MIC level two designations (29 definitions as of 2023) to their final industry designations.[1]

Exhibit A1

McKinsey Industry Classification (MIC) Industries	New industry mapping used in final data set	
Advanced electronics	• Consumer durables • Industrial electronics	• Industrial machinery • Semiconductors
Aerospace and defense	• Aerospace and defense	
Agriculture and food production	• Agriculture	
Air and travel	• Air services • Travel and leisure	
Apparel, fashion, and luxury	• Apparel and luxury	
Automotive and assembly	• Automotives • Electric vehicles	• Industrial equipment
Banks	• Retail and commercial banks	
Basic materials	• Building materials and products • Construction engineering and services	• Forest products and packaging • Mining
Business services	• Information-enabled business services • Recruiting and staffing services	• Other business services
Chemicals	• Chemicals	
Conglomerates	• Conglomerates	
Consumer durables	• Consumer durables • Consumer electronics	
Consumer packaged goods	• Beverages • Home and personal goods • Leisure products	• Packaged food • Tobacco

[1] Because of the six industries that appear in multiple MIC level two classifications, this list has 63 items instead of 57, with six duplicates.

Exhibit A1 (continued)

McKinsey Industry Classification (MIC) Industries	New industry mapping used in final data set
Consumer services	• Consumer services • Restaurants and food service
Diversified financials	• Nonbank financials • Payments
Healthcare providers	• Healthcare
Healthcare supplies and distribution	• Healthcare
High tech	• Cloud services • Hardware • Information-enabled business services • IT solutions and services • Software
Insurance	• Insurance • Life insurance
Logistics and trading	• Freight and logistics • Wholesale trading
Media	• Consumer internet • Gaming • Media • Video and entertainment
Medical technology	• Medical technology
Oil and gas	• Oil and gas
Pharma and biotech	• Biopharmaceuticals • Pharmaceuticals
Real estate	• Chinese real estate • Real estate (excl China)
Retail	• Consumer internet • E-commerce • Everyday and general retail
Telecom	• Telecom
Transport and infrastructure	• Air services • Freight and logistics • Rail and transport
Utilities	• Electric power • Other utilities

Computing growth rates and shuffle rates

The growth rate measures the increase in the overall revenue or market capitalization share of an industry. For example, the industry with the highest revenue growth rate in the period we considered was e-commerce, which had a 0.08 percent share in 2005 and a 2.36 percent share in 2020, an increase of 2.28 percentage points—the growth rate metric for e-commerce. The industry with the lowest revenue growth rate was oil and gas, with a 5.48 percentage-point decrease. E-commerce had the highest growth rate for market cap, at 3.64 percentage points. Retail and commercial banks had the lowest growth rate for market cap, at −6.41 percentage points.

A negative growth rate did not necessarily mean that an industry was shrinking, but rather that its shares of the total revenues in our database had decreased. Oil and gas registered revenue growth from 2005 to 2020, for example, but other industries outpaced it. Similarly, retail and commercial banks increased their market cap from 2005 to 2020 but grew at a slower pace than other industries.

The relevant formulas are as follows:

$$Industry\ share_t = \frac{revenue\ industry}{\sum revenue\ industries} \text{ or } Industry\ share_t = \frac{market\ capitalization\ industry}{\sum market\ capitalization\ industries}$$

$$Industry\ growth\ rate = Industry\ share_{2020} - Industry\ share_{2005}$$

The shuffle rate measures the change in players' market shares within an industry. An example appears in chapter 1, in the sidebar "Industry dynamism measured by share shifts." To compute the shuffle rate of a given industry, we started with the percentage-point changes in revenue or market cap share of each player from 2005 to 2020. We then added up all the positive percentage-point changes for each player.

For example, cloud services had the highest revenue shuffle rate at 94 percentage points, while aerospace and defense had the lowest revenue shuffle rate at 15 percentage points. In market cap shuffle rate, electric vehicles had the highest at 95 percentage points, while aerospace and defense had the lowest at 28 percentage points.

The formulas appear below:

$$Company\ share = \frac{Company\ revenue}{Industry\ revenue} \text{ or } Company\ share = \frac{Company\ market\ capitalization}{Industry\ market\ capitalization}$$

$$\Delta\ Company\ share = Company\ share_{2020} - Company\ share_{2005}$$

$$Industry\ shuffle\ rate = \sum positive\ \Delta\ Company\ shares = \sum \frac{|\Delta\ Company\ shares|}{2}$$

One can also think of the growth rate as a metric that measures change across industries, while the shuffle rate measures change within industries.

In this report, we showed combined industry shuffle rates and industry share growth rates of market capitalization and revenue as bubble charts. Exhibits A2 and A3 are individual charts for each of the four dimensions relevant to demonstrating the arenas' growth and dynamism.

Exhibit A2

In terms of market cap, arenas of today ranked high in both industry share growth rates and shuffle rates.

Market cap industry share growth rates and shuffle rates for 57 industries

Arenas of today | Other industries

Industry share growth rate (change in share of global increase in market cap), 2005–20, percentage points

Shuffle rate (increase in market cap share among companies in each industry), 2005–20, percentage points

Note: Based on McKinsey Industry Classification; Quality 4 & 5 data from McKinsey Value Intelligence, PitchBook only; subsidiaries excluded; includes only firms with market cap >$3.5B in 2005 or >$5B in 2020; number of firms by arena varies; firms identified as did not exist/nonpublic in '05 based on no McKinsey Value Intelligence market cap data in 2005.
Source: McKinsey Value Intelligence; McKinsey Global Institute analysis

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Exhibit A3

In terms of revenue, current arenas mostly ranked high in both industry share growth rates and shuffle rates.

Revenue industry share growth rates and shuffle rates for 57 industries

Arenas of today | Other industries

Industry share growth rate (change in share of global increase in revenue), 2005–20, percentage points

Shuffle rate (increase in revenue share among companies in each industry), 2005–20, percentage points

Note: Based on McKinsey Industry Classification; Quality 4 & 5 data from McKinsey Value Intelligence, PitchBook only; subsidiaries excluded; includes only firms with market cap >$3.5B in 2005 or >$5B in 2020; number of firms by arena varies; firms identified as did not exist/nonpublic in '05 based on no McKinsey Value Intelligence market cap data in 2005.
Source: McKinsey Value Intelligence; McKinsey Global Institute analysis

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Selection of the 12 arenas of today

Three criteria were used in selecting the 12 current arenas: a high growth rate, a high shuffle rate, and a minimum market cap in 2020.

We first ranked the 57 industries by their growth rates and shuffle rates for both revenue and market cap, with one the highest and 57 the lowest. We then created a composite score by adding the four ranks of each industry—their growth and shuffle rates for both revenues and market cap. In theory, this would mean that if an industry ranked the highest in growth rate and shuffle rate for both revenues and market cap, it would have a score of one for all four metrics, for a total composite score of four. By contrast, if the industry ranked the lowest for all four metrics, or a score of 57 for each, it would have a total composite score of 228.

We filtered out arenas with market capitalization of less than $800 billion in 2020.

Exhibit A4 lists the top 20 industries by composite scores.

Exhibit A4

Industry	Growth rate rank		Shuffle rate rank		Composite score	Market capitalization, 2020, $ billion
	Revenues	Market cap	Revenues	Market cap		
E-commerce	**1**	**2**	**4**	**6**	**13**	**3,159,988**
Consumer internet	**3**	**3**	**3**	**13**	**22**	**3,512,452**
Chinese real estate	2	18	2	5	27	471,010
Cloud services	**16**	**7**	**1**	**1**	**25**	**1,170,976**
Electric vehicles	**15**	**9**	**8**	**2**	**34**	**1,032,856**
Consumer electronics	**12**	**6**	**5**	**8**	**31**	**2,448,163**
Payments	**19**	**4**	**13**	**3**	**39**	**1,711,654**
Biopharmaceuticals	**8**	**8**	**14**	**12**	**42**	**2,430,432**
Agriculture	11	24	6	7	48	231,362
Software	**9**	**1**	**9**	**29**	**48**	**3,951,295**
Industrial electronics	**7**	**10**	**20**	**17**	**54**	**2,005,936**
Video and entertainment	**13**	**11**	**16**	**18**	**58**	**1,452,765**
Consumer durables	22	25	10	9	66	256,630
Information-enabled business services	**26**	**14**	**19**	**22**	**81**	**887,741**
Construction engineering and services	6	40	12	24	82	316 ,193
Travel and leisure	41	26	7	14	88	787,597
Gaming	23	19	36	28	106	443,961
Semiconductors	**10**	**5**	**45**	**37**	**97**	**3,426,539**
Recruiting and staffing services	29	33	28	10	100	118,952
Healthcare	4	22	55	19	100	786,405

The 12 industries with the lowest composite scores (indicating highest growth and shuffle rates) and a market capitalization of at least $800 billion in 2020 made up our final list of 12 current arenas.

Other analyses

GDP contribution analysis. We first identified the overall industry sizes of the 12 arenas in 2005 and 2020. This was required as the revenues presented in chapter 1 only include companies in the analyzed sample, and hence represent only a subset of the total industry. Overall industry sizes were obtained from McKinsey databases, such as the Global Payments Map, as well as third-party information sources, such as Statista . For instances where 2005 data was unavailable, the respective arena 2005–20 CAGR was applied to 2020 data to determine the 2005 industry size by working backward. As a result, the overall revenue size of the 12 arenas is estimated at $2.8 trillion in 2005 and $13.4 trillion in 2020.

To estimate the GDP contribution of the 12 arenas, we first tried to identify the appropriate ratio to apply to revenues, to arrive at gross value added (the "ratio"). We used data from the US Bureau of Economic Analysis (BEA), which contains value-added and gross-output data from 58 industries. We calculated the ratio between value added and gross output across these 58 industries from 2005 to 2020.

We then mapped each of the 12 arenas with the most closely linked BEA industries and identified the ratio most appropriate for each arena. For instance, the consumer electronics arena was mapped to the BEA industry labeled "computer and electronic products." This industry had an average ratio of 0.66 from 2005 to 2020. The industrial electronics arena was mapped to the BEA industry labeled "machinery," which had an average ratio of 0.38. We also looked at the variances of the ratios across years. While some industries (such as motion picture and sound recording) showed volatility, those contributed a relatively small proportion of the sample.

We then applied the respective ratios to each of the 12 overall arena industry sizes to identify the estimated GDP equivalent of arenas. When compared with GDP, this estimated arena GDP contribution came to $1.6 trillion in 2005 and $7.7 trillion in 2020.

Sensitivity analysis. To test for sensitivity, we replicated analyses of the six key metrics that differentiated arenas from other industries listed in chapter 1 to account for significant global events such as the financial crisis of 2007–08 and the start of the COVID-19 pandemic in 2020. For example, we looked at the movements in economic profit and revenue and market cap growth rates from 2005 to 2019 (instead of 2020), which resulted in the same outcomes. The takeaways from all analyses held across all of these checks.

R&D analysis. Company reported R&D expenses were both incomplete and inconsistent at the firm level within the top 3,000 companies' databases. We instead used publicly available data. We used publicly available data from the US National Center for Science and Engineering Statistics, specifically its Business Enterprise Research and Development (BERD) Survey. We took the total domestic US private-sector spending on R&D in 2005 and 2020 at the most granular level possible. This resulted in 54 different industries defined by the BERD survey. We mapped these 54 industries as either arenas (and arena-adjacent) or non-arenas. For example, we mapped an industry named "software publishers" in the BERD survey to an arena (software). For large industries such as pharmaceuticals and medicines, we divided these data points into two categories: pharmaceuticals (not an arena) and biopharmaceuticals (an arena). The proportion of this split was based on the revenues of these two industries as listed in the main McKinsey Value Intelligence data set. The same logic was used to calculate R&D to revenue ratios for arenas and non-arenas, using publicly available data from the same source on 2020 R&D intensity. R&D intensity is defined as the cost of US spending on R&D divided by US net sales of companies that performed or funded R&D.

Spawning giants analysis. To analyze the share of total market cap of large market cap companies within arenas and non-arenas, we have used the same McKinsey Value Intelligence company-level data as was used to identify arenas of today. Companies were grouped by market cap size according to the following criteria: i) market cap lower than $50 billion; ii) market cap between $50 billion and $200 billion; iii) market cap equal to or larger than $200 billion. To get to the percentage share of these companies in arenas and non-arenas, we divided the number of companies in each of these three market cap size categories by the total number of companies in arenas and non-arenas. To get to the percentage share of total arenas' and non-arenas' market cap held by companies in these three categories, we have divided the market cap value held by each of these categories by total arenas and non-arenas market caps.

Revenue sources by geographies analysis. To analyze the source countries of our companies' revenues, we also used the McKinsey Value Intelligence database, which breaks down company revenues by country. We then mapped these data points individually into two groups: domestic, if the source country was where the company was headquartered, and international, if the revenues were from outside the home country. In the rare instances where the split was unavailable, we would by default select the revenue earned domestically.

Chapter 2

Early markers of arenas analysis

We used data from PitchBook to identify venture capital (VC) and IPO flows from 2003 to 2007. PitchBook categorizes VC and IPO flows in two ways: by industry and by vertical. PitchBook has 215 industries and 59 verticals. A transaction is mapped to an industry and at least one vertical. For example, if VC flows went to a company that provides software for virtual reality gaming, the company would be mapped to application software (industry) and tagged to gaming (vertical) and virtual reality (vertical).

We mapped these 215 industries and 59 verticals to our 12 arenas to the extent possible. In a few instances, the industries or verticals were mapped to several arenas. For example, PitchBook has an entertainment software industry. This was mapped to two arenas: software, and video and entertainment. PitchBook also has a mobile vertical. This was mapped to two arenas: consumer electronics and consumer internet.

We removed instances when a transaction was counted twice because the industry-vertical combination was mapped to the same arena. For instance, a transaction tagged to the application software industry (mapped to the software arena) with an AI and machine-learning vertical (also mapped to the software arena) was counted only once for the software arena's total.

However, some double counting was unavoidable when a transaction was mapped to several verticals mapped to different arenas. For example, if the transaction went to a company that provided an e-commerce application on phones, it could be tagged to three verticals: e-commerce (mapped to the e-commerce arena), mobile (mapped to the consumer electronics arena), and software as a service (mapped to the software arena). In this case, while there was no double counting within the three arenas mapped, the transaction was included in the totals of these three arenas. We estimated these instances of multiple counting of arenas at around 20 percent of the overall value; they did not materially change the takeaways of the analysis.

Chapter 3

NOPLAT estimates used

Various benchmarks were used to identify the net operating profit less adjusted taxes (NOPLAT) margin assumptions used for chapter 3, Exhibit 14. The primary intent of using NOPLAT estimates

was to give readers an important additional layer of considerations aside from the potential revenues presented in the exhibit.

For most of these arenas, all three of our general approaches to benchmarking used historical 2022 NOPLAT margins.

The first approach was used for continuing and spin-off arenas. The benchmark for these arenas was the originating arena. Seven arenas fell into this category: e-commerce, AI software and services, electric vehicles, digital ads, cloud services, semiconductors, and streaming video. We then adjusted our assumptions based on the 2022 NOPLAT of the originating arena, given the uncertainty surrounding the evolution of the economics of these arenas. For example, e-commerce saw a 3 percent NOPLAT in 2022 from the same data set we used in chapter 1. We then ranged this 3 percent and used a 2 to 5 percent assumption. Similarly, we used the NOPLAT benchmark of 13 percent for video and audio entertainment (an originating arena) as our base assumption for the streaming video potential future arena. This was then ranged to 10 to 15 percent.

The second approach was for potential future arenas that were closely linked to any of the 57 industries in our chapter 1 data set (the 57 are identified above). Seven arenas belonged to this category: shared autonomous vehicles, space, cybersecurity, video games, industrial and consumer biotech, modular construction, and future air mobility. We took all relevant industries connected to these potential future arenas and used the range of those numbers as our benchmark. In instances when only one industry was used as the benchmark, we ranged those numbers as well, in a similar way to the ranging we did in the first approach in the previous paragraph. For instance, aerospace and defense saw an 8 percent NOPLAT in 2022, which we ranged from 5 to 10 percent.

The last approach was for potential future arenas that had existing companies that could be reasonably used as benchmarks. We considered companies that were relatively mature, because their economics and margins were likely more stable than those of newer companies or start-ups. Four potential future arenas were in this category: batteries, drugs for obesity and related conditions, nuclear fission power plants, and robotics. For example, we used Eli Lilly and Novo Nordisk as our benchmarks for drugs for obesity and related conditions.

GDP contribution analysis

To estimate the GDP contribution of the potential arenas of tomorrow in both 2022 and 2040, we followed the same general approach discussed above in chapter 1. We first tried to identify the appropriate ratio to apply to revenues to estimate value added and applied those ratios to the estimated arena sizes in 2022 and 2040.

We used data from the US BEA, which contains value-added and gross-output data from 58 industries. We then mapped the 18 arenas of tomorrow with the most closely linked BEA industries. For instance, the modular construction arena was mapped to the “construction” industry, and the cybersecurity arena was mapped to the “computer systems design and related services” industry. These mappings were then matched with the respective value-added to gross-output ratios from 2005 to 2020, which were mostly stable. These ratios were then multiplied on the respective low and high case revenue estimates for each of the 18 arenas. This resulted in an estimated total GDP equivalent of $4.2 trillion in 2022 and $16.4 trillion to $26.9 trillion for the low and high cases, respectively, in 2040.

To estimate overall GDP, we used GDP data from the World Bank for 2022 as our starting point for global GDP. The growth rate we used was 2.85 percent, the rate estimated by the OECD for OECD and G-20 countries from 2020 to 2040.

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