



CHARTING DISRUPTION

GLOBAL X

by Mirae Asset

OUTLOOK FOR
2024 AND BEYOND



For more than a decade, our mission has been empowering investors with unexplored and intelligent solutions.

 Headquartered in New York, with Global X ETFs listed throughout Europe, Asia, Latin America, and Australia.



Global X ETFs is a fully-owned subsidiary of Mirae Asset Financial Group, a global industry leader with 55 offices and over 12,000 employees worldwide. Founded in 1997 as one of Asia's pioneering fund management companies, the Group now oversees **\$565bn in client assets** across a portfolio that includes real estate, insurance, private equity, and venture capital.²

\$46bn in AUM across more than 200 ETF strategies¹

Primary Listings by Office



United States

107 ETF Listings



Europe

34 UCITS ETF & 5 Crypto ETP Listings



Australia

35 ETF Listings



Latin America

32 ETF Listings in Brazil & Colombia



Hong Kong

27 ETF Listings



Japan

36 ETF Listings

¹As of October 31, 2023 ²As of June 30, 2023

Charting Disruption 2024

Our future constantly develops and changes right in front of us. Yet much of the potential disruption seems unimaginable—until it happens.

Our flagship research project, Charting Disruption, aims to shed a quantifiable light on what the future may hold. It's where we explore the interplay between innovation and emerging technological as well as behavioral trends that can shape financial markets and their performance.

In charting potential disruption, we think it's helpful to zoom out to get a more complete view of where technology was and how far it's come. The advances in just the last 25 years alone prove momentous and the momentum of this trend of innovation continues.

It wasn't that long ago, for example, that people found it challenging to envision a world linked through smartphones and the internet. Before too long, most people won't be able to remember life without them.

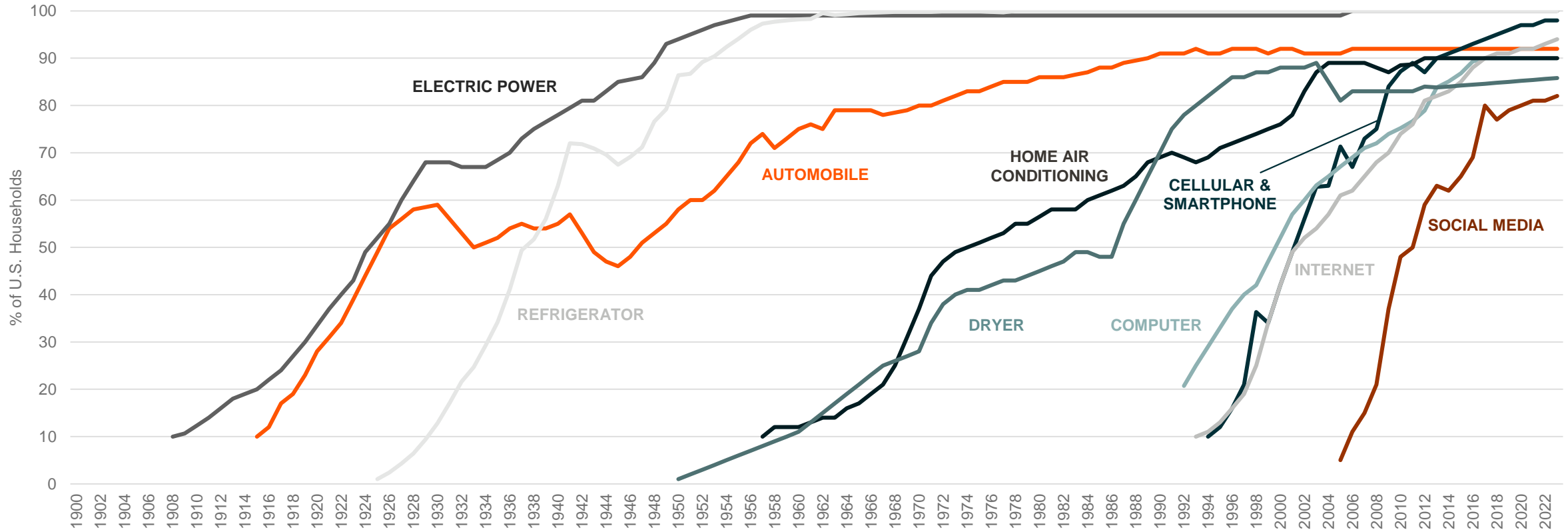
To explore the depth of changes like these, we partnered with handpicked experts in fields such as Artificial Intelligence, Digital Assets, CleanTech, Autonomous Vehicles, Genomics & Biotech, Battery Technology, and Food Innovation.

In what follows, we present unique forecasts, datasets, and analyses that reveal what we expect to disrupt our world in 2024 and beyond.

We hope you enjoy and gain a better understanding of what's possible.

Zooming Out for a Comprehensive View of Disruption

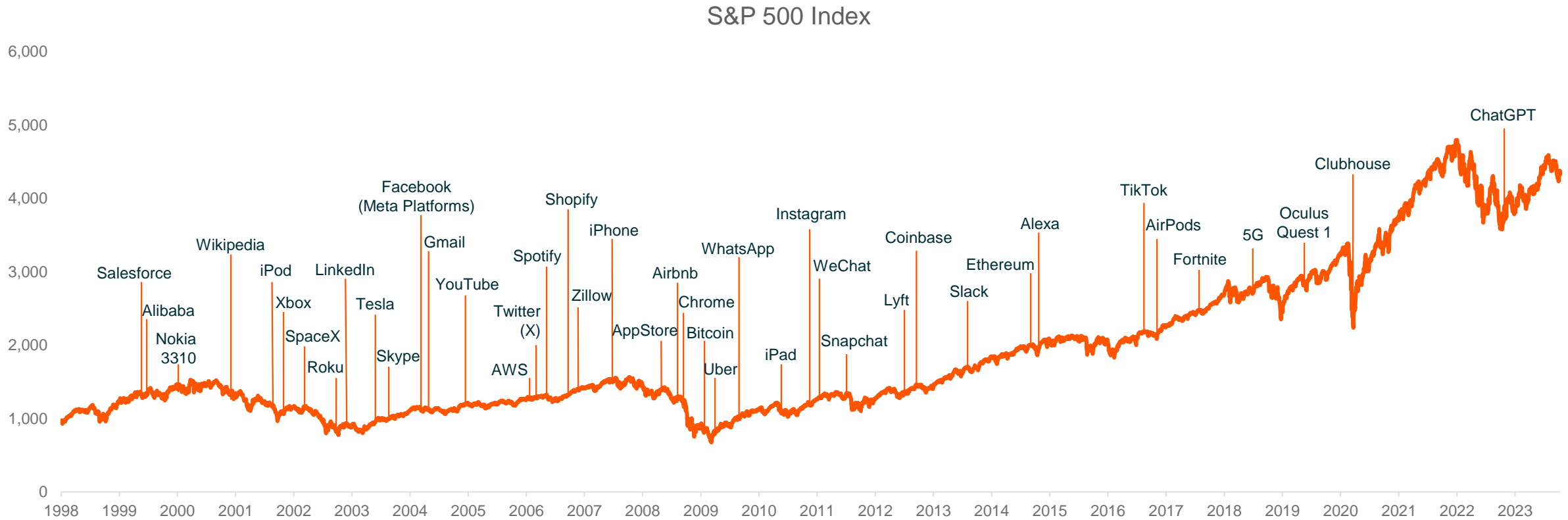
We may often underestimate how much the world can change within a lifetime. Recognizing past dramatic shifts can help us envision a vastly different world in the years or decades ahead.



Sources: Our World in Data. (2019, July 27). Share of United States Households Using Specific Technologies.

Things That Didn't Exist 25 Years Ago

Throughout market cycles, innovation has not stopped. What's familiar to us today – social media, mobile payments, or e-commerce – was unimaginable to our ancestors a few generations ago.

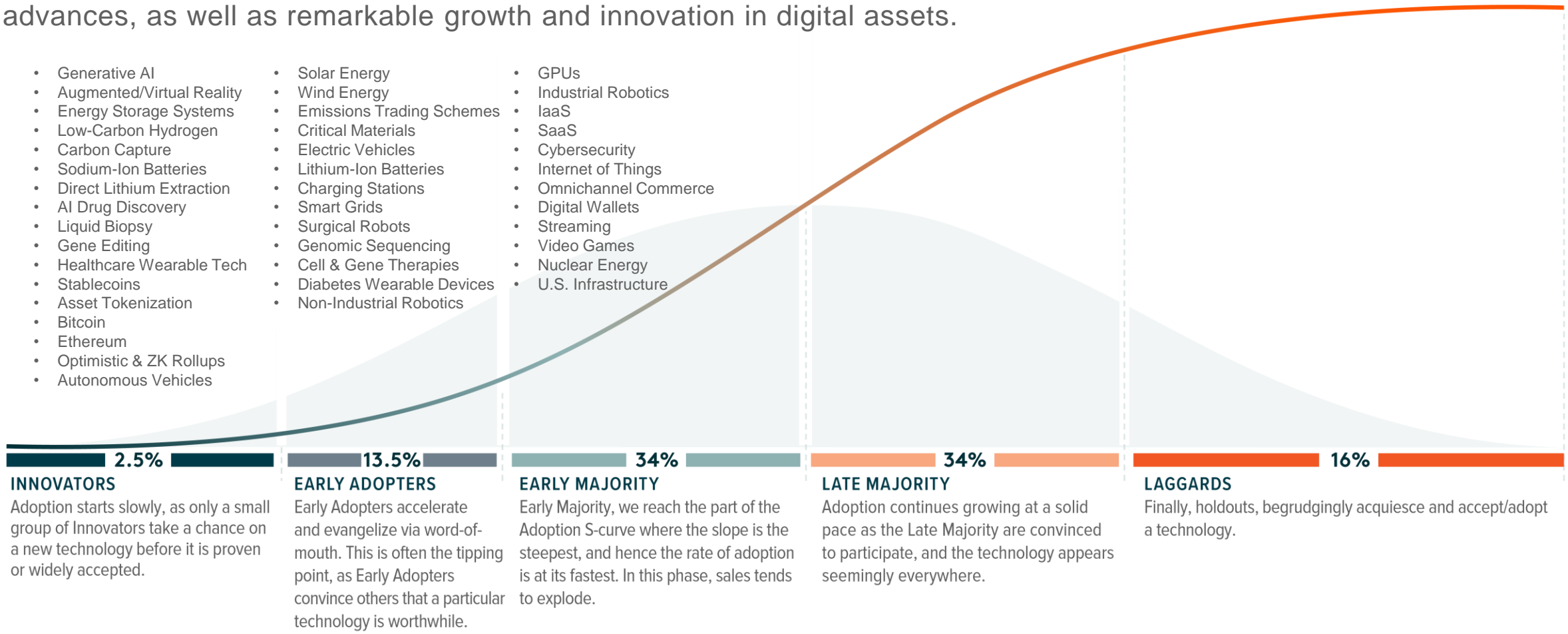


Source: Bloomberg, L.P. (n.d.). [S&P 500 Index] [Data set]. Retrieved on October 13, 2023 from Global X ETFs Bloomberg terminal.

The Unimaginable Today Will Be Familiar Tomorrow

Anticipate a future marked by groundbreaking technologies, greener solutions to global issues, pioneering medical advances, as well as remarkable growth and innovation in digital assets.

- Generative AI
- Augmented/Virtual Reality
- Energy Storage Systems
- Low-Carbon Hydrogen
- Carbon Capture
- Sodium-Ion Batteries
- Direct Lithium Extraction
- AI Drug Discovery
- Liquid Biopsy
- Gene Editing
- Healthcare Wearable Tech
- Stablecoins
- Asset Tokenization
- Bitcoin
- Ethereum
- Optimistic & ZK Rollups
- Autonomous Vehicles
- Solar Energy
- Wind Energy
- Emissions Trading Schemes
- Critical Materials
- Electric Vehicles
- Lithium-Ion Batteries
- Charging Stations
- Smart Grids
- Surgical Robots
- Genomic Sequencing
- Cell & Gene Therapies
- Diabetes Wearable Devices
- Non-Industrial Robotics
- GPUs
- Industrial Robotics
- IaaS
- SaaS
- Cybersecurity
- Internet of Things
- Omnichannel Commerce
- Digital Wallets
- Streaming
- Video Games
- Nuclear Energy
- U.S. Infrastructure



INNOVATORS

Adoption starts slowly, as only a small group of Innovators take a chance on a new technology before it is proven or widely accepted.

EARLY ADOPTERS

Early Adopters accelerate and evangelize via word-of-mouth. This is often the tipping point, as Early Adopters convince others that a particular technology is worthwhile.

EARLY MAJORITY

Early Majority, we reach the part of the Adoption S-curve where the slope is the steepest, and hence the rate of adoption is at its fastest. In this phase, sales tends to explode.

LATE MAJORITY

Adoption continues growing at a solid pace as the Late Majority are convinced to participate, and the technology appears seemingly everywhere.

LAGGARDS

Finally, holdouts, begrudgingly acquiesce and accept/adopt a technology.

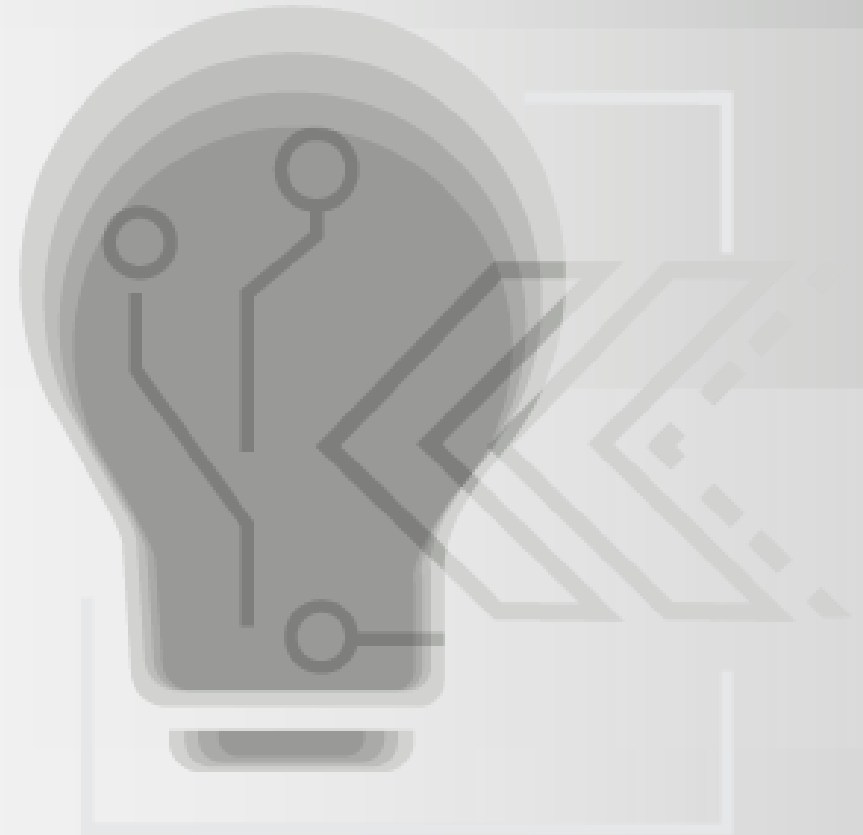
PHASES OF ADOPTION

Displayed for illustrative purposes. Curve shape not indicative of mathematical transformation.

Charting Disruption 2024

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Paradigm-Shifting Technologies



Paradigm-Shifting Technologies

Artificial Intelligence

Generative AI's Transformative Power

Large Language Models (LLMs) mark a revolutionary change in artificial intelligence's (AI's) development, as they make sophisticated AI accessible, integrable, and widely distributable. While early proof of concepts present only a hint of what's possible with generative AI, they clearly show that we're on the cusp of a new paradigm where consumer experiences and enterprise applications are intelligent and interactive by design. We expect this shift to create new markets amid a multi-trillion-dollar explosion of economic value.

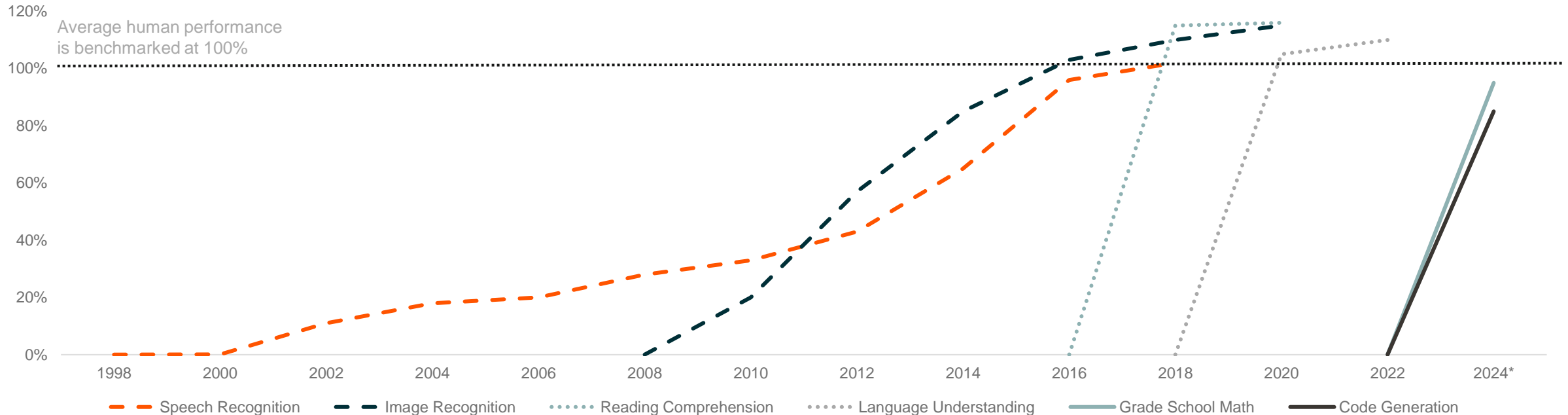


AI Already Outperforms Humans in Numerous Categories

AI's performance superiority is evident for tasks like reading comprehension and language understanding, and the pace of its development for more novel tasks is accelerating. However, Artificial General Intelligence (AGI) is still years away.

AI Is Likely to Surpass Humans in All Performance Benchmarks by the End of This Decade

AI Performance on Benchmarks, Relative to Human Performance



* Forecast

Note: For each benchmark, the maximally performing baseline reported in the benchmark paper is taken as the "starting point", which is set at 0%. Human performance is set at 100%.

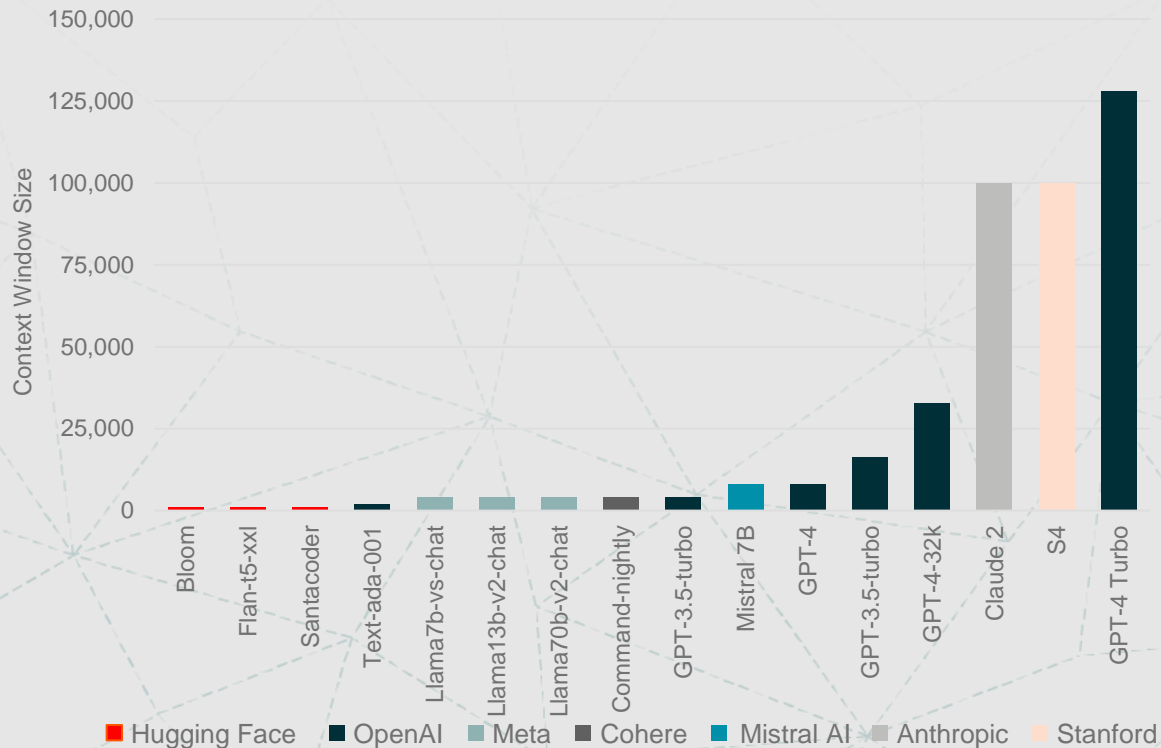
Sources: Kiela, Thrus, Ethayarajh, & Singh, 2023; Henshall, 2023

Advancements in Transformer Models Can Propel Increased Adoption

Andrew Carr

LLMs based on the attention mechanism come with high computational costs. Emerging model paradigms will focus on improving model accuracy and increasing context sizes while keeping costs and hallucinations at a minimum.

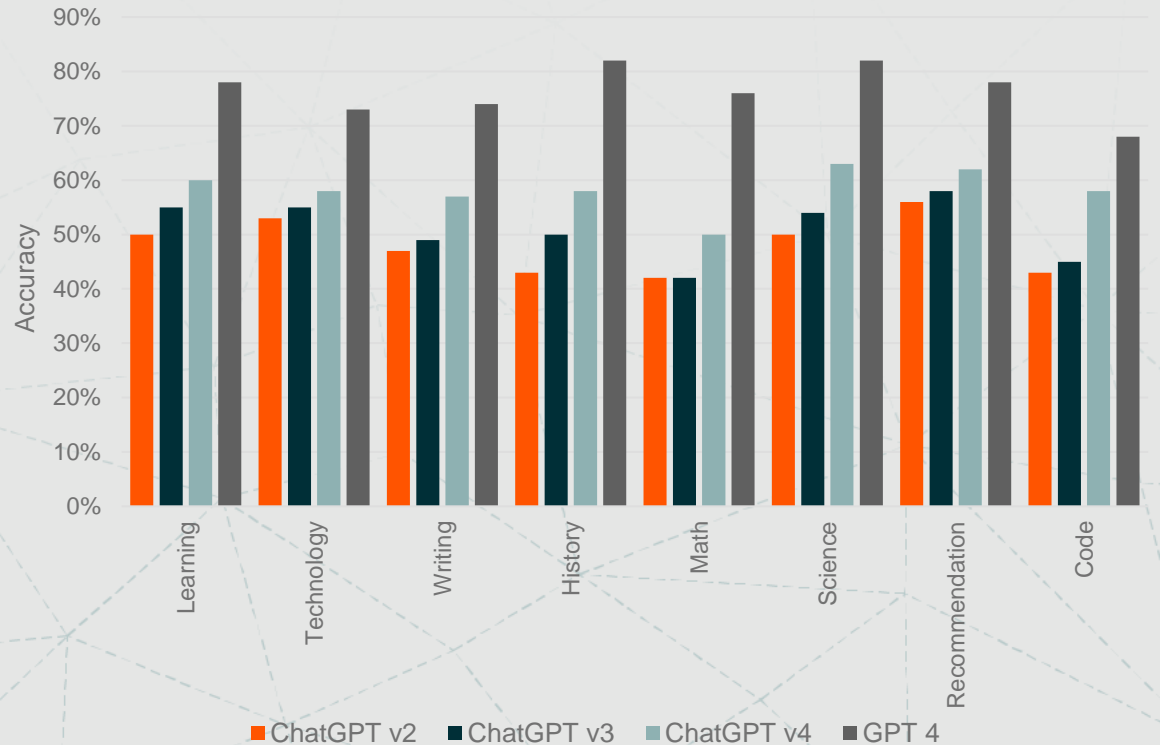
Large Language Model Context Sizes



Note: The context window is the number of tokens the model can take as input. Attention mechanisms allow the model to selectively focus on specific parts of the input most important for making a prediction.

Sources: Charts: Left: Greyling, 2023; Right: OpenAI, 2023

OpenAI Internal Accuracy Evaluation by Category

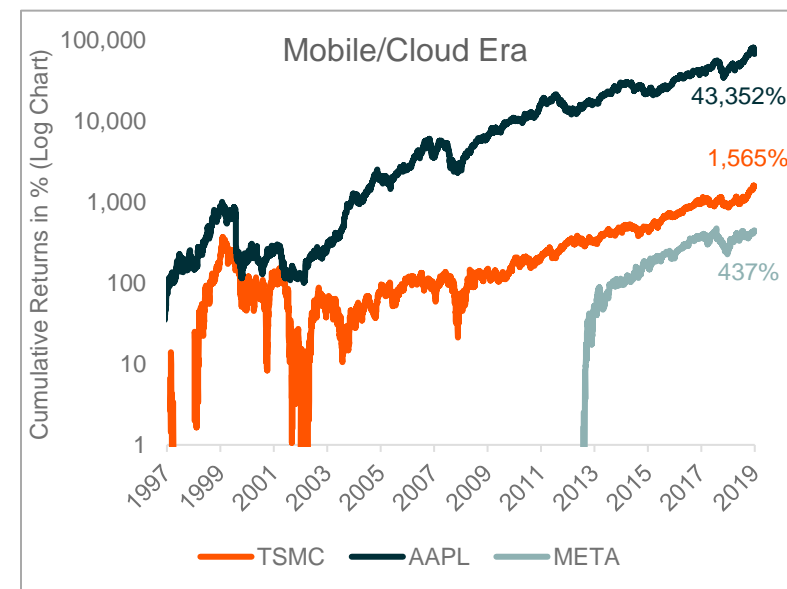
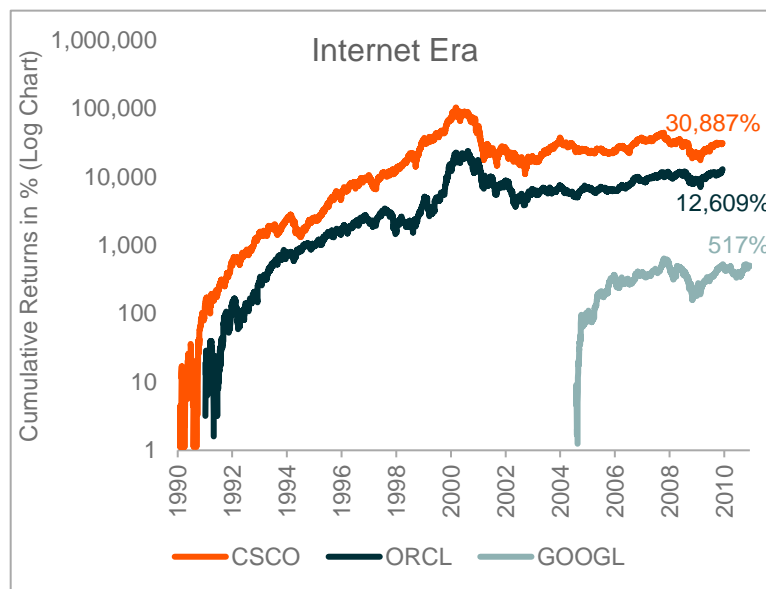
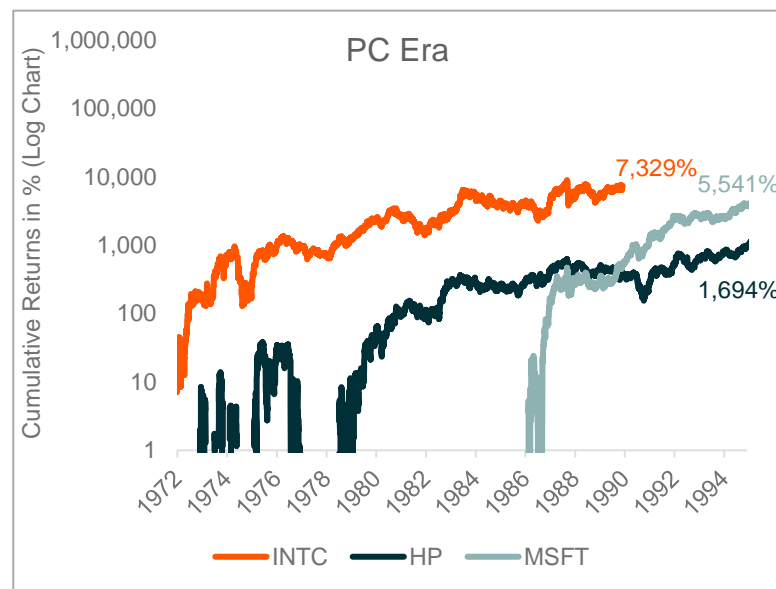


Note: An accuracy of 1.0 means the model's answers are judged to agree with human ideal responses for all questions in the evaluation.

Generative AI to Deliver Another Major Technological Paradigm Shift

Technological paradigm shifts rely on the convergence of three elements: compute, data/infrastructure, and interface. Companies that met the demand of their respective categories in previous shifts have become market winners.

Compute Layers / Compute Eras	Personal Computers (PCs)	Internet	Mobile/Cloud	AI
Compute	Intel	Intel, Cisco	Samsung, Qualcomm, TSMC	Nvidia, ARM
Data / Infrastructure / Device	Hewlett-Packard (HP)	Cisco, Oracle	AWS, iOS, Android	AWS, Azure, GCP
Interface	Microsoft	Google, Amazon	Meta, Apple, Google, Samsung	OpenAI, TBD

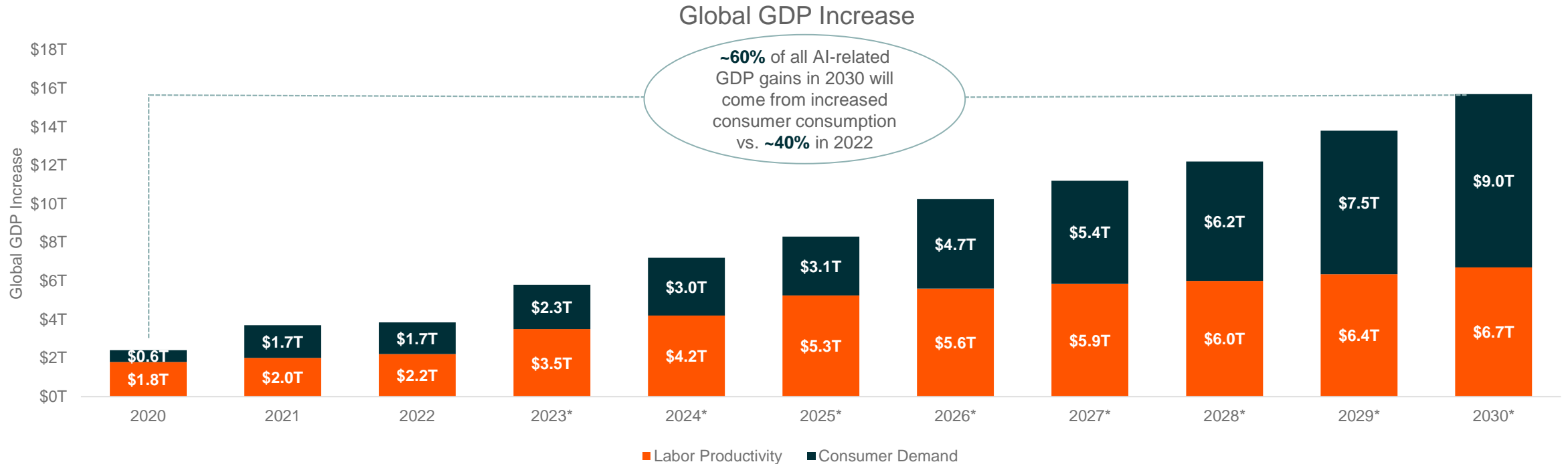


Sources: Charts: Top: The Deload, 2023; Bottom: FactSet, n.d.

AI's Rapid Advancement Could Add \$16 Trillion to the Global Economy by 2030¹

Initial growth will primarily stem from productivity gains before gradually shifting to an expansion driven by increased consumer demand.

Generative AI Will Enhance Labor Productivity and Could Drive Higher Consumer Demand Through Improved Product Quality



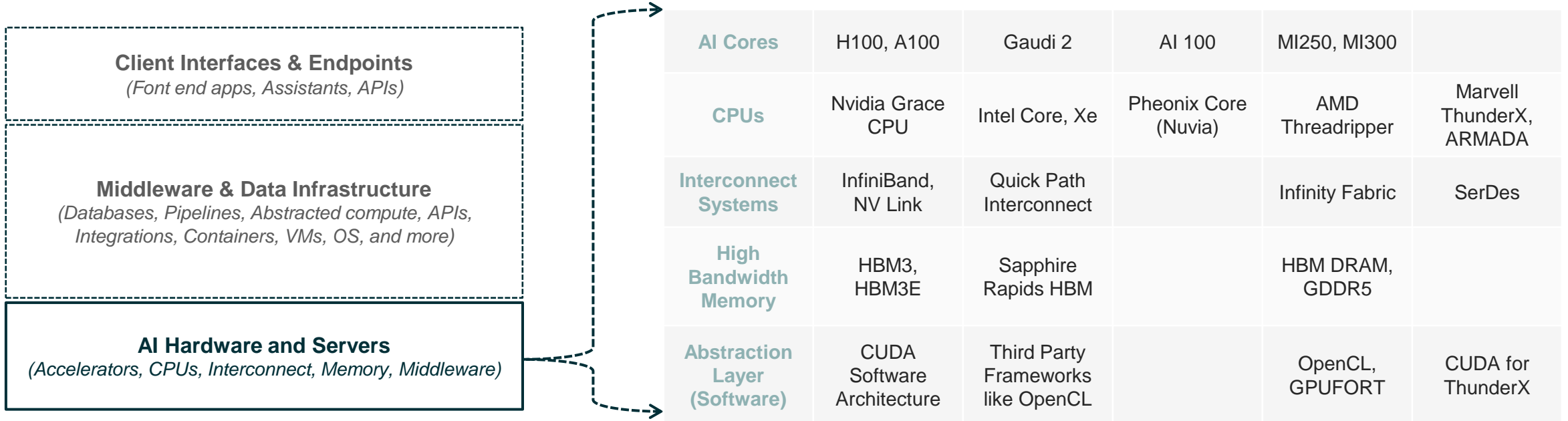
Sources: Text: 1 Bank of America, 2023; Chart: Bank of America, 2023; Medium, 2023

Revamp of AI Processing Infrastructure Presents New Opportunities for Chipmakers

As data center systems transition to computational infrastructure that can handle AI-first workloads, we expect new opportunities to emerge for disruptive chipmakers.



AI Computational Stack



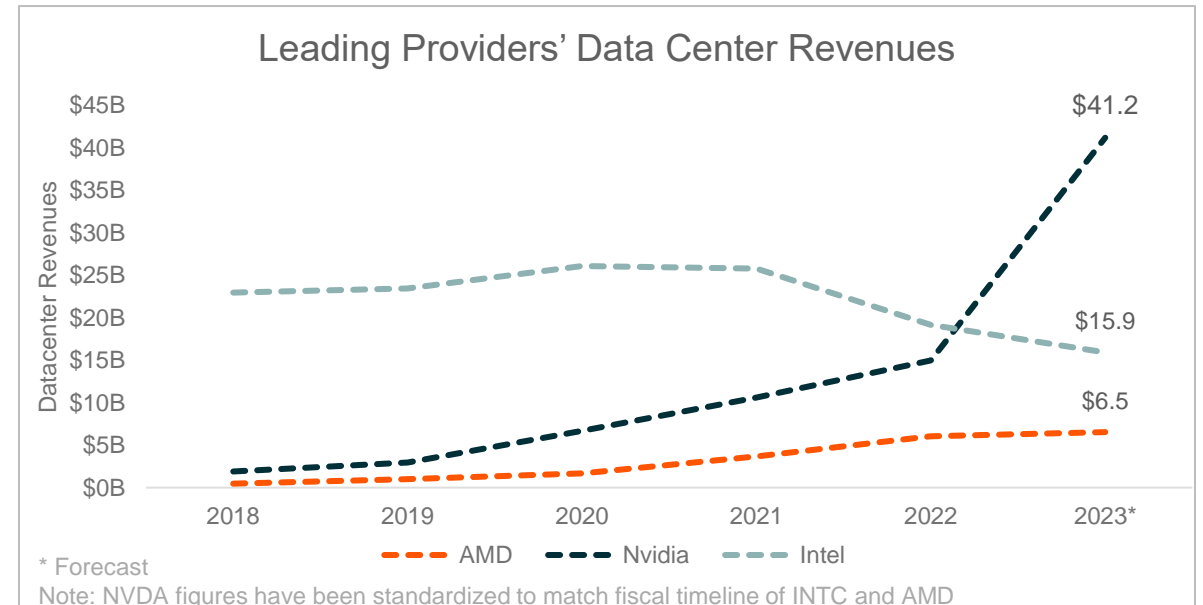
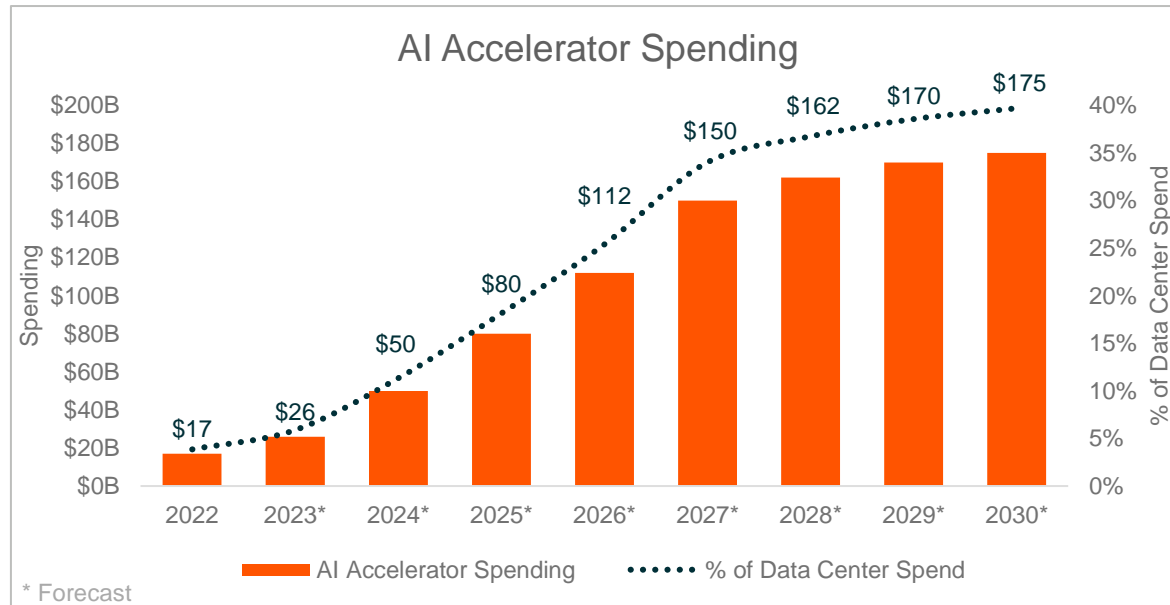
Sources: The Next Platform, 2021; Nvidia, n.d.; Intel, n.d.; Qualcomm, n.d.; Advanced Micro Devices (AMD), n.d.; Marvell, n.d.

The AI Chipset Market Could Be Worth More Than \$200 Billion by the End of the Decade

The graphics processing unit (GPU) market is projected to exceed \$247 billion by 2028, and the broader AI accelerator market is expected to approach \$162 billion.^{1,2}

AI accelerators are specialized hardware components designed to perform the complex computations required by AI and machine learning (ML) algorithms more efficiently than general-purpose central processing units (CPUs). In addition to GPUs, other accelerators include field-programmable gate arrays (FPGAs), application-specific integrated circuits (ASICs), and Tensor Processing Units (TPUs).

Nvidia currently owns a more than 70% share in datacenter acceleration, but vendors like AMD are making strides.³ AMD is moving fast to build a foothold and meet surging AI demand, including by bringing its new MI300 accelerator chip to the market.



Sources: Text: 1. Precedence Research, 2023; 2 Bloomberg, 2023; 3. Visual Capitalist, 2023; Charts: Left: Precedence Research, 2023; Bloomberg, 2023; Statista, 2022; Right: FactSet, 2023

Open-Source Models Allow for Robust AI Innovation Outside Big Tech's Control

Andrew Carr

The open-source community is gaining momentum with industry giants such as Meta Platforms releasing models. This community also excels in curating small datasets that the public can use to fine-tune these models.



	Alphabet	Amazon	Microsoft/OpenAI	Meta Platforms	Nvidia	Stability AI	Additional Contributors
Text / Language	Bard, BERT, PaLM, GLaM, Chinchilla	AlexaTM, Titan LLM	GPT-4, ChatGPT, MT-NLG	LLaMA, OPT-175B	MT-NLG		Claude, Cohere, Jurassic-1, Dolly, BLOOM, Alpaca
Code	AlphaCode	Code Whisperer	Copilot, Codex, CodeBERT	Code LLaMA			Replit, Polycoder, Code T5
Image	Parti, DreamBooth, Imagen		Dall-E 2, Kosmos-2, CLIP, NUWA-Infinity	Dinov2, Make-a-scene	SPADE	Stable Diffusion	Midjourney, Waifu Diffusion
Speech & Music	WaveNet, MusicLM		Whisper, Jukebox			Dance Diffusion	WaveGAN
Video	Imagen Video, Phenaki		NUWA-Infinity	Make-a-video			CogVideo
3D	DreamFusion, 3DiM		Point-E		Get3D, Magic3D		Motion Diffusion Model

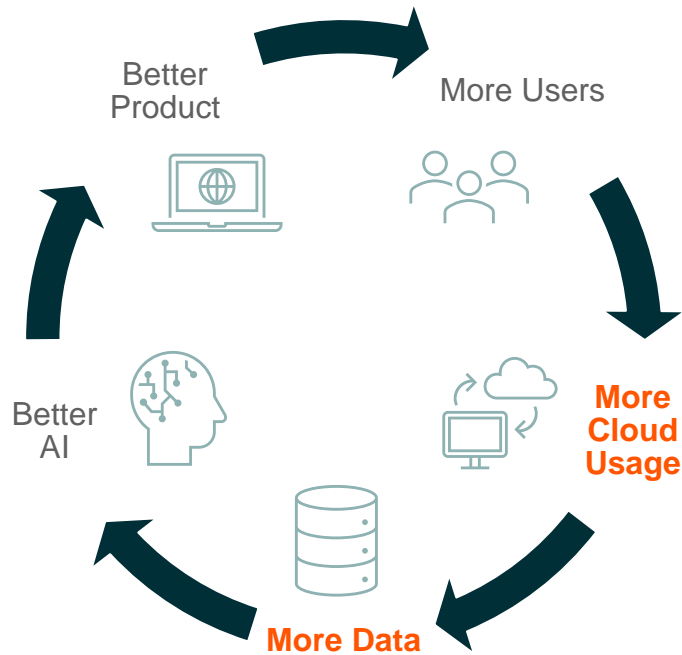
■ Proprietary
 ■ Open Source
 ■ Private

Source: Tola Capital, 2023

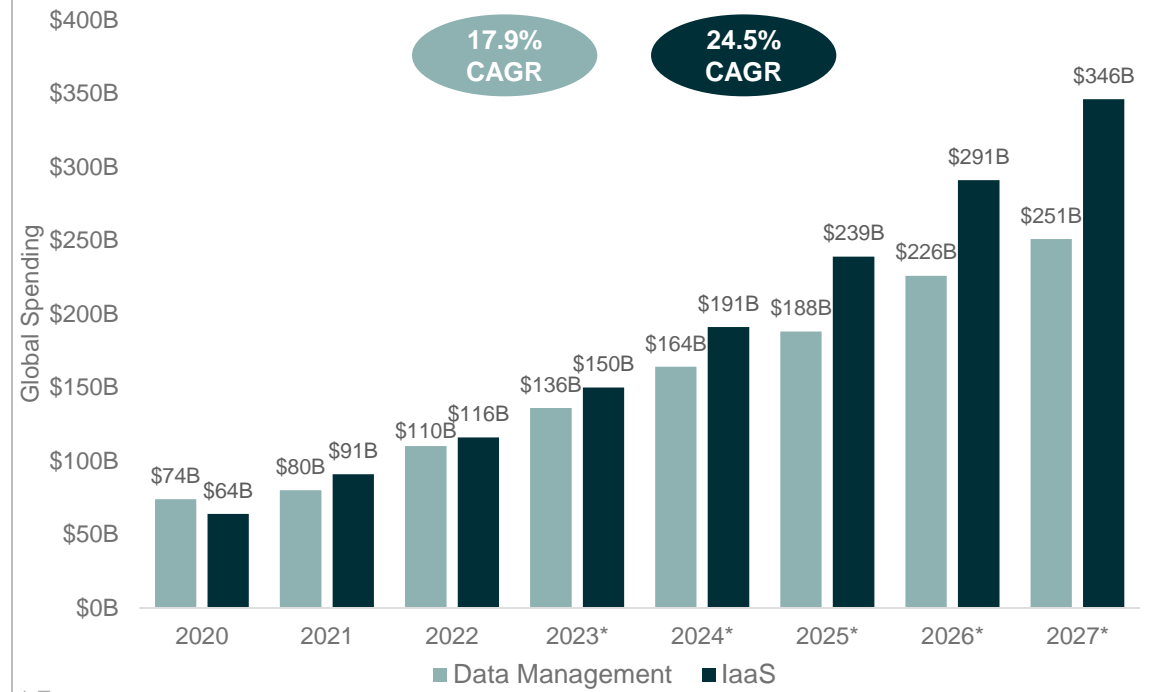
AI Implementation Benefits Cloud Infrastructure Providers and Data Solutions Suppliers

AI services will largely be distributed and consumed through the public cloud. Data management solutions and apps are essential for enterprises looking to extract insights from the explosion of data and enhance their offerings.

Data Explosion Increases Demand for Cloud Resources



Data Management Spend Expected to Grow at 18% CAGR



Sources: Charts: Right: Gartner, 2023; Research and Markets, 2023

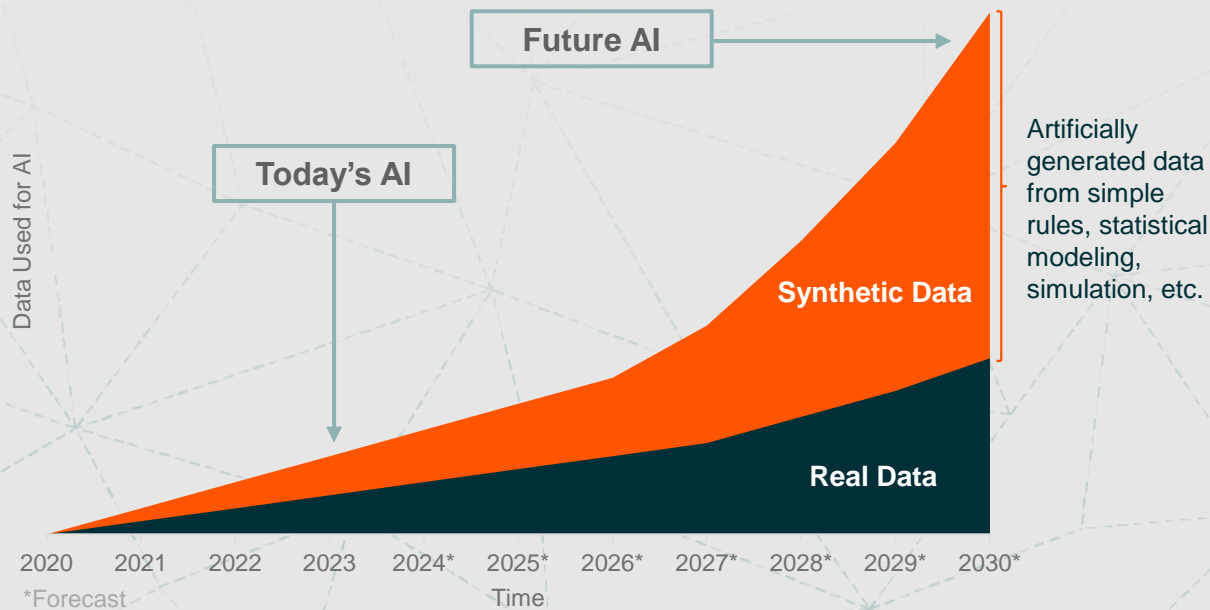
Emerging Model Architectures Benefit from Synthetic Data

Andrew Carr

Trillions of data points go into training the best of these models. What happens when we run out of data? How do we train the next generation of models? Synthetic data is a potential answer.

Synthetic Data: Manufactured, Not Based on Real-World Events

Real Data vs. Synthetic Data in AI Models



Synthetic Data Benefits



Cost Savings

Overcome the data gap and reduce the overall expense of obtaining and annotating data needed to train AI models.



Accuracy

Create highly accurate, generative AI models by training with data including rare, crucial corner cases otherwise impossible to collect.



Privacy

Tackle privacy concerns and reduce bias by creating varied datasets that mirror the real world.



Scalable

Generate data that scales with your use case across manufacturing, automotive, robotics, and more.

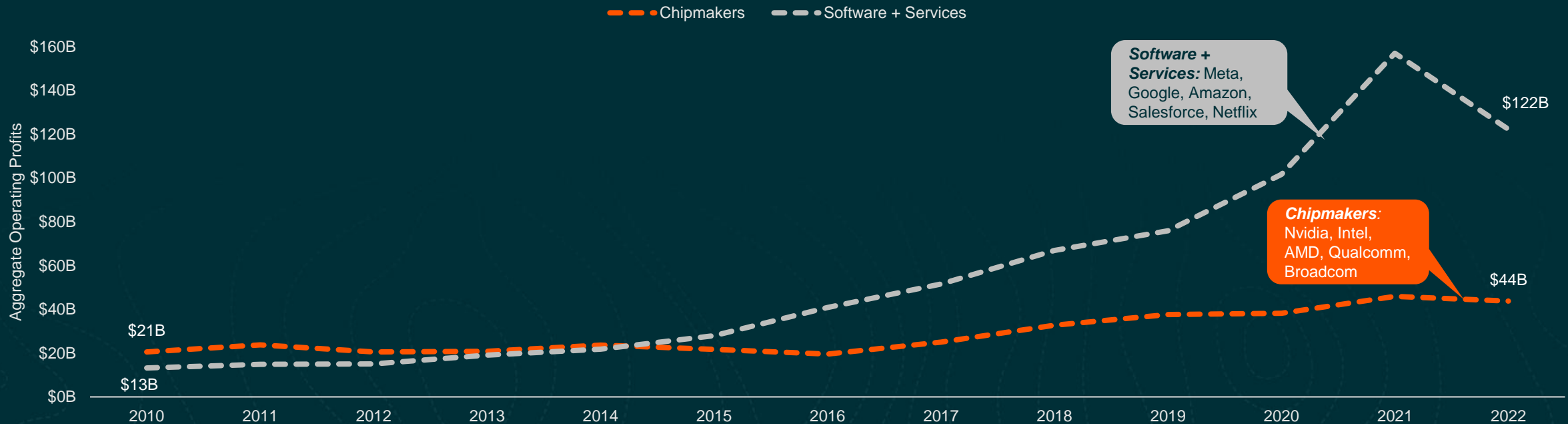
Sources: Charts: Left: Gartner, 2021; Right: Nvidia, n.d.

History Suggests Interface Layer Will Capture Maximum Value from the AI Platform Shift

The interface layer is how consumers experience paradigm shifts. Like Microsoft did for PCs and Apple did for smartphones, the apps that integrate generative AI models into user-facing products can accrue incredible value.

Services Providers and Platforms, Created by a New Tech Cycle, Reap Better Profits Than Chipmakers Powering the Cycle

Software & Services vs. Chipmakers Cohort Operating Profits, 2010-2022



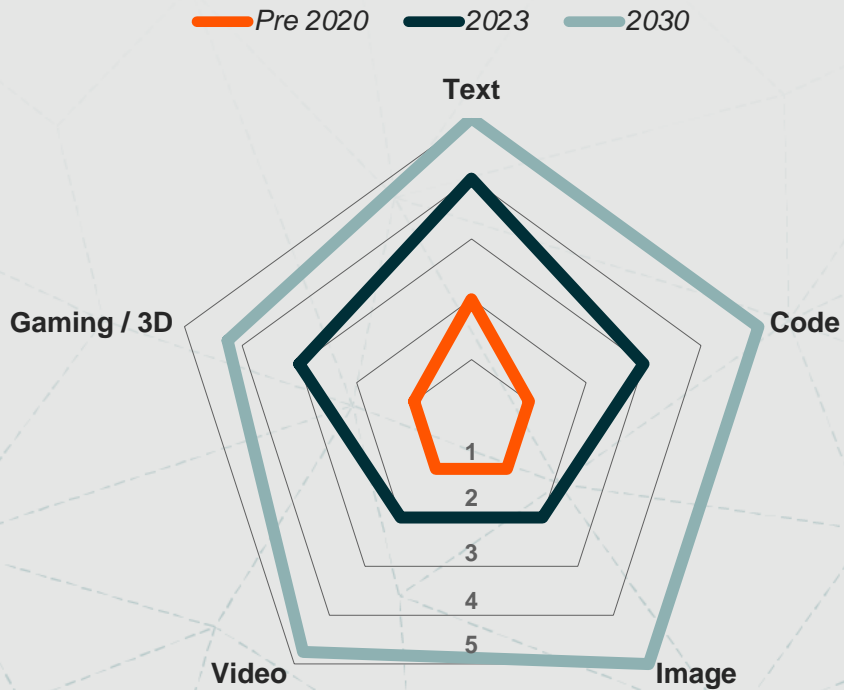
Sources: FactSet, n.d.

Multimodal LLMs Can Bring AI Closer to Widespread Consumer Application

Andrew Carr

Editability and flexibility are keys to advancing LLMs. Multimodal LLMs, which combine text with other data, like images, videos, or animation, can address the limitations of text-only models and unlock new applications and uses.

Generative AI Capabilities by Different Modalities



Note: Scale 1-5, with 5 being most capable

Sources: Charts: Right: The Information, 2023

Leading AI Players Race Towards Multi-Modal LLMs

Google Gemini

Google's inhouse AI group, DeepMind, will launch Gemini in 2024. Gemini is a multimodal LLM that enables users to generate content based on various inputs, write software code, summarize content, as well as draft emails and song lyrics.

As the impact of AI broadens and new use cases emerge, large data-rich tech players, like Google, intend on being the engine of creativity while creating new business models by supplying multi-modal systems.

OpenAI GPT-Vision and Gobi

OpenAI is developing a new multi-modal AI model called Gobi, which will learn from the company's GPT-based system and integrate multi-modal capabilities.

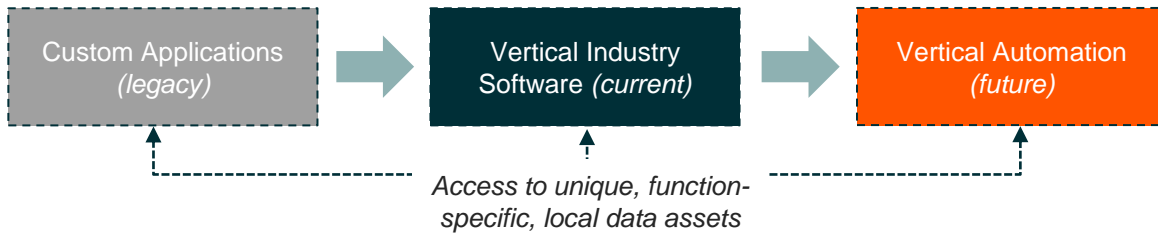
Open AI has also recently launched GPT-Vision, a multimodal feature that equips GPT-4 with image comprehension abilities, broadening the range of applications it offers its users.

This enhancement enables new image-based applications for GPT-4, such as generating text that matches images.

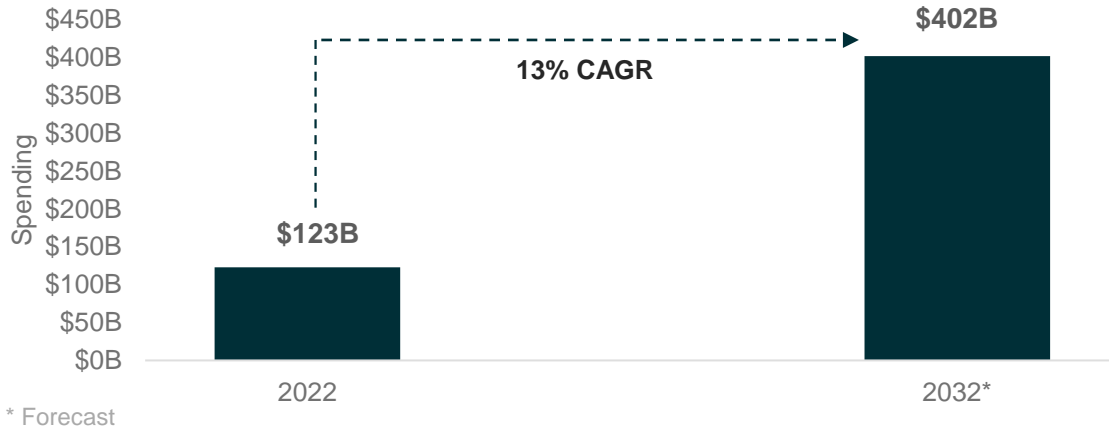
New AI-Embedded SaaS Applications Will Continue to Emerge Through the Decade

Vertical automation is the future. SaaS providers are in a unique position to leverage data assets at their disposal to train foundational models and bring them to market to automate industry-specific systems.

Software Moving from Custom-Built to Verticalized Intelligence



Vertical Software Market Spend



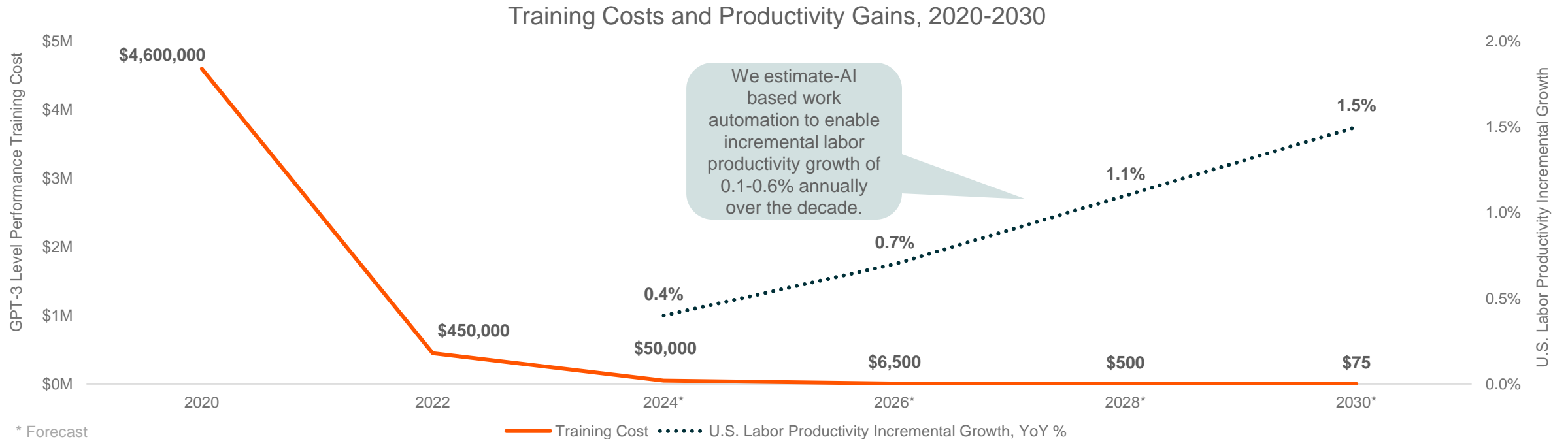
Platform	Tool	Function
Salesforce	Einstein GPT	Auto-generates sales, marketing, content, targeting, messaging, and personalization across channels.
Adobe	Firefly	Generates images, fill, text effects, and recolor from text prompts. Can also create content and edit video with text prompts.
Meta	AI Sandbox	Tools that enable businesses to create AI-based ads and better predict performance.
Microsoft	365 Copilot	Generates tasks, word-processing documents, presentations, spreadsheets, emails, and Microsoft office updates via text prompts.
Google	Workspace Bard	Generates drafts, replies, and proofs in Gmail and Google Docs; images, audio and video in Slides; and notes/audio in Meet.
Canva	Magic Write	Generates drafts, outlines, lists, and captions from text prompts.
HubSpot	ChatSpot	Conversation bot that automates all customer relationship management tasks.
Grammarly	GrammarlyGo	Generates writing and revisions relevant to tone, clarity, length, and tasks via text prompts across various forums.

Sources: Charts: Left: Future Market Insights Inc., 2022; Right: Quesenberry, 2023

AI to Emerge as a Co-Pilot to Human Intelligence

AI is already dramatically increasing knowledge workers' productivity. As adoption intensifies, AI hardware, software, and training costs are expected to decline, promoting even greater adoption and productivity.

Cost of Training a GPT-3 Level LLM Declined by About 90% from 2020-2022, Which Could Reignite Productivity Growth

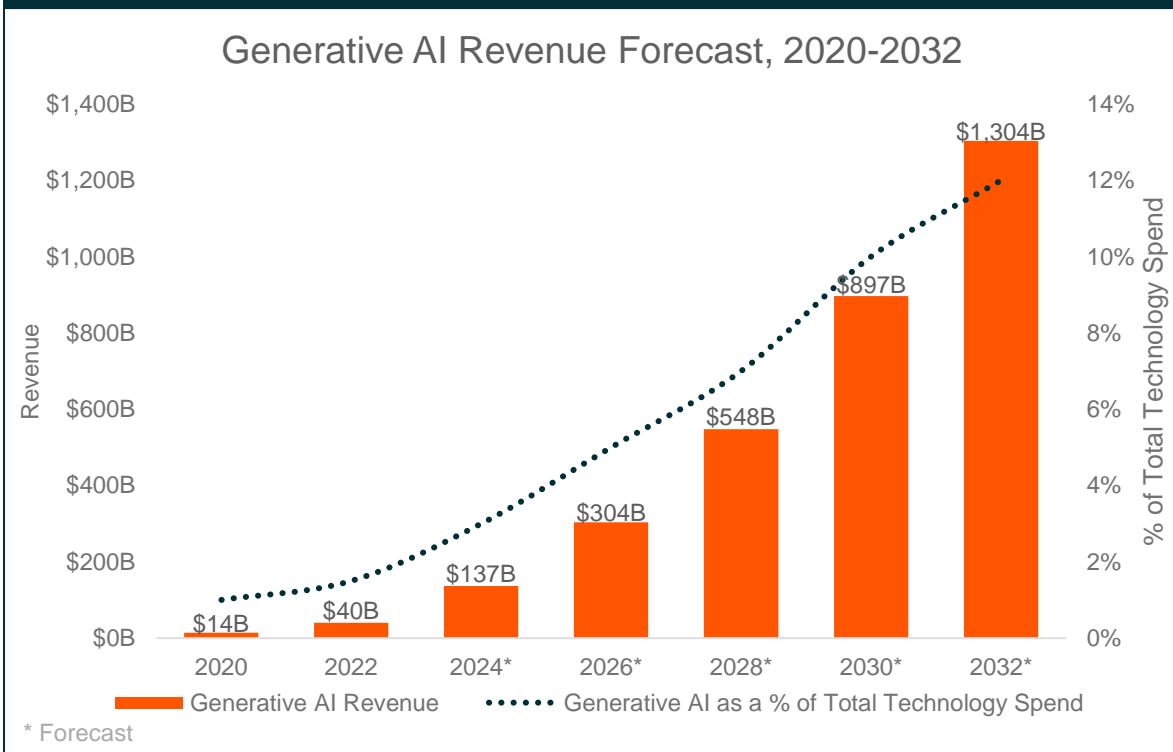


Note: U.S. Productivity Growth measures the incremental YoY boost to labor productivity, measured as output per hour worked, of non-farm business employees, delivered by increased use of automation in work. Sources: McKinsey & Company, 2023; MosaicML, 2022; Lambda, 2020; U.S. Bureau of Labor Statistics, 2023

Generative AI-Based Technology Could Account for \$1.3 Trillion in Spending By 2032¹

Generative AI growth will be largely driven by training infrastructure in the near term before gradually shifting to specialized software and services over the longer term.

Gen AI to Comprise ~10% of Tech Spending by 2030



Generative AI Revenue Projections (\$M)	2022	2027*	2032*	CAGR
Hardware	\$37,973	\$223,615	\$641,737	33%
Devices (Inference)	\$4,128	\$82,965	\$168,233	45%
Computer Vision AI Products	\$1,032	\$22,124	\$60,564	50%
Conversational AI Products	\$3,096	\$60,841	\$107,669	43%
Data Center/Infrastructure (Training)	\$33,845	\$140,650	\$473,505	30%
AI Server + Storage	\$31,588	\$82,735	\$226,459	22%
Generative AI Infrastructure as a Service	\$2,256	\$57,915	\$247,046	60%
Software	\$1,493	\$58,826	\$279,899	69%
Specialized Generative AI Assistants	\$447	\$20,864	\$89,035	70%
Coding, DevOps, and Gen AI Workflows	\$213	\$12,617	\$50,430	73%
Gen AI Workload Infrastructure Software	\$439	\$13,468	\$71,465	66%
Gen AI Drug Discovery Software	\$14	\$4,042	\$28,343	113%
Gen AI Based Cybersecurity Spending	\$9	\$3,165	\$13,946	109%
Gen AI Education Spending	\$370	\$4,669	\$26,500	53%
Other Software Spending	\$368	\$116,904	\$381,915	100%
Total	\$39,834	\$399,345	\$1,303,551	42%

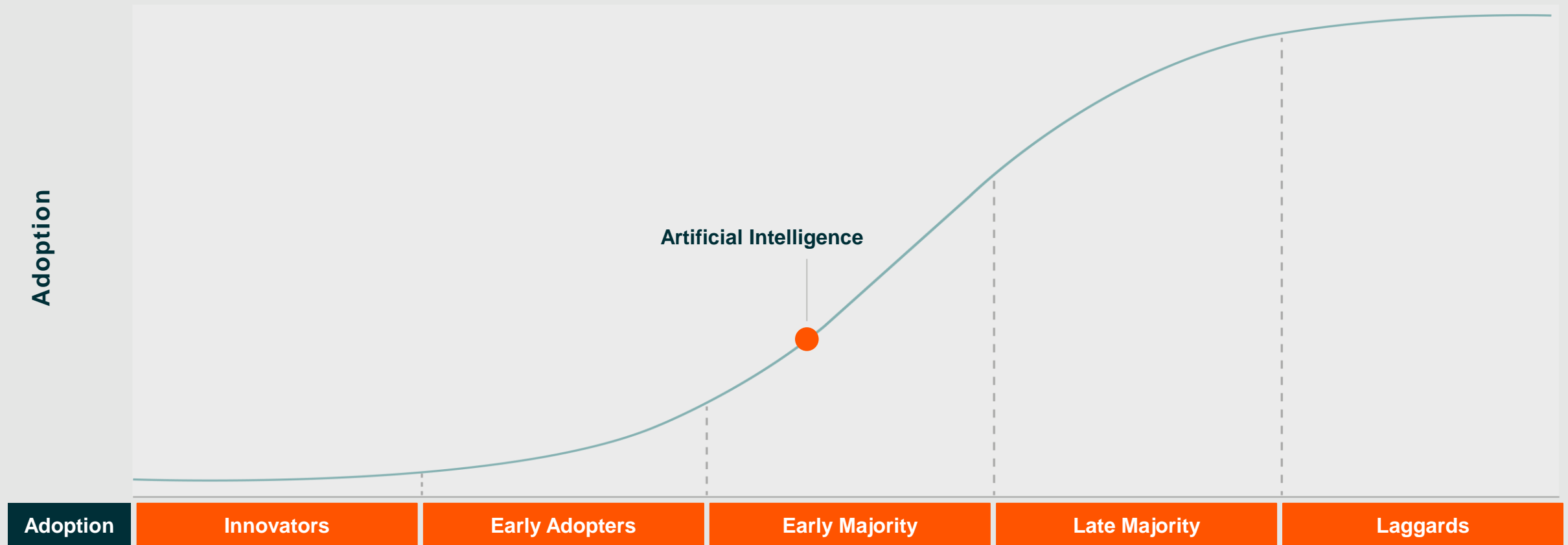
* Forecast

Notes: CAGR = 2022-2032E; Other Software Spending includes Gen AI Gaming spend, Gen AI Ad spend, Gen AI IT spend, Gen AI Business Service spend.

Sources: Text: 1. Bloomberg, 2023; Charts: Bloomberg, 2023

Artificial Intelligence: S-Shaped Curve of Adoption

Generative AI generated revenues of roughly \$40 billion in 2022. That figure is expected to top \$1.3 trillion by 2032, representing a 40%+ compound annual growth rate (CAGR).¹



Note: For illustrative purposes only.
Sources: Text: 1 Bloomberg, 2023

Paradigm-Shifting Technologies

Cloud Computing

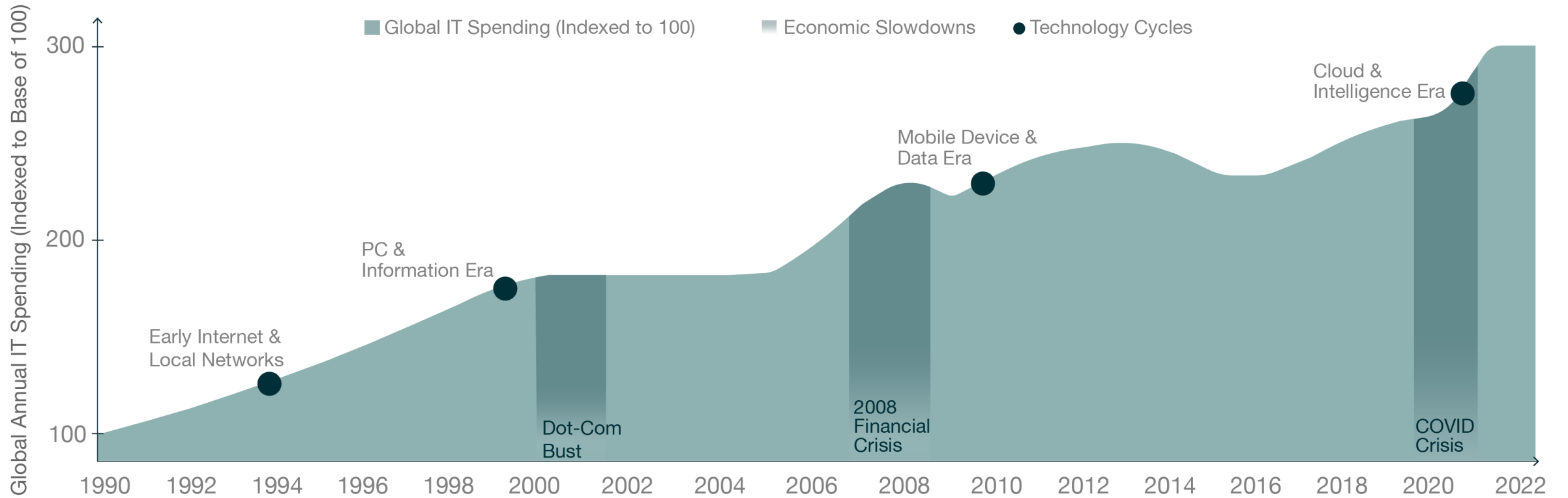
Navigating New Realms

Cloud computing is central to modern information technology (IT), and now the default way to build, deploy, and manage computing resources. In the last 24 months, IT's transition to the cloud entered an optimization phase as macroeconomic conditions shifted. However, we still expect the cloud market to grow through this decade, driven by the broad data explosion and the adoption of emerging technologies like artificial intelligence (AI). Cybersecurity challenges will also present opportunities for growth.



Emerging Platforms and Shifting Economic Conditions Spurred Computing's Evolution

Computing evolved through multiple cycles, going from a decentralized on-premise model to a much more efficient centralized hyperscale model over the past 30 years, driving a jump tripling IT spending.

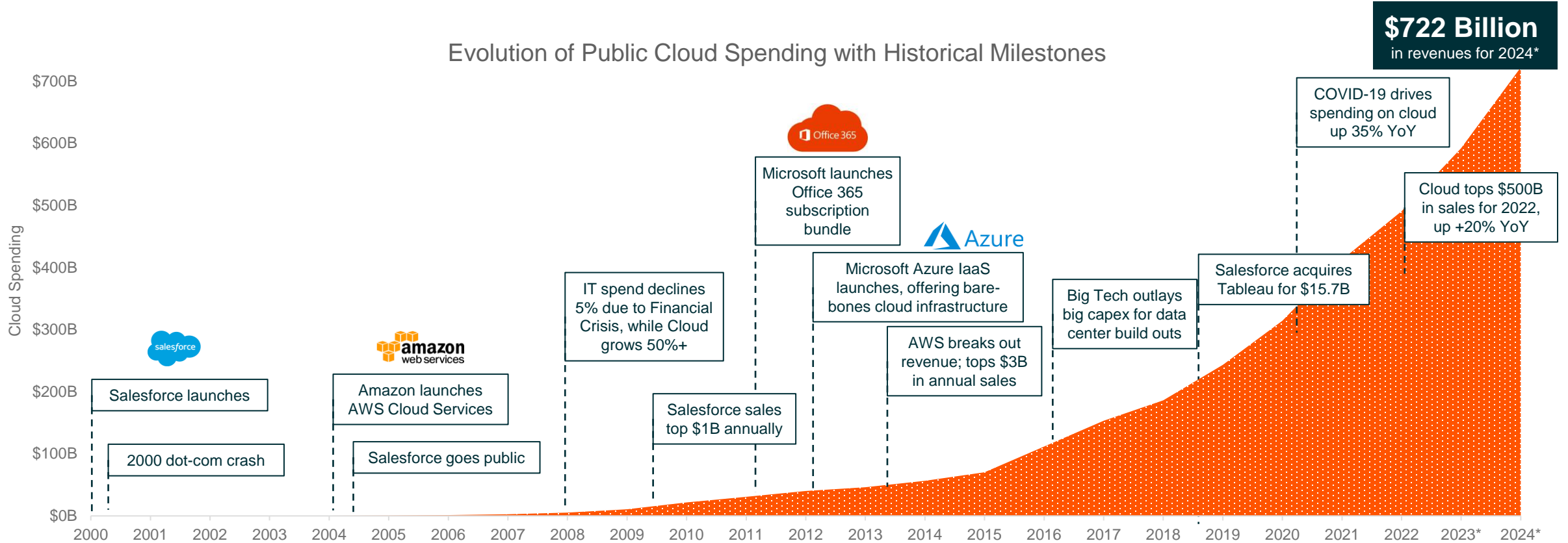


Sources: Gartner, 2022; Gartner, 2023; Weatherly Asset Management, 2022

Modern Computing Continues to Evolve with Cloud and Hyperscaling at Its Core

Cloud achieved parabolic scale due to the data explosion, need for ubiquitous access to information, and resultant productivity gains. Cloud revenue in 2025 could equal the cumulative revenue of the 20 years before COVID-19.

Evolution of Public Cloud Spending with Historical Milestones



* Forecast

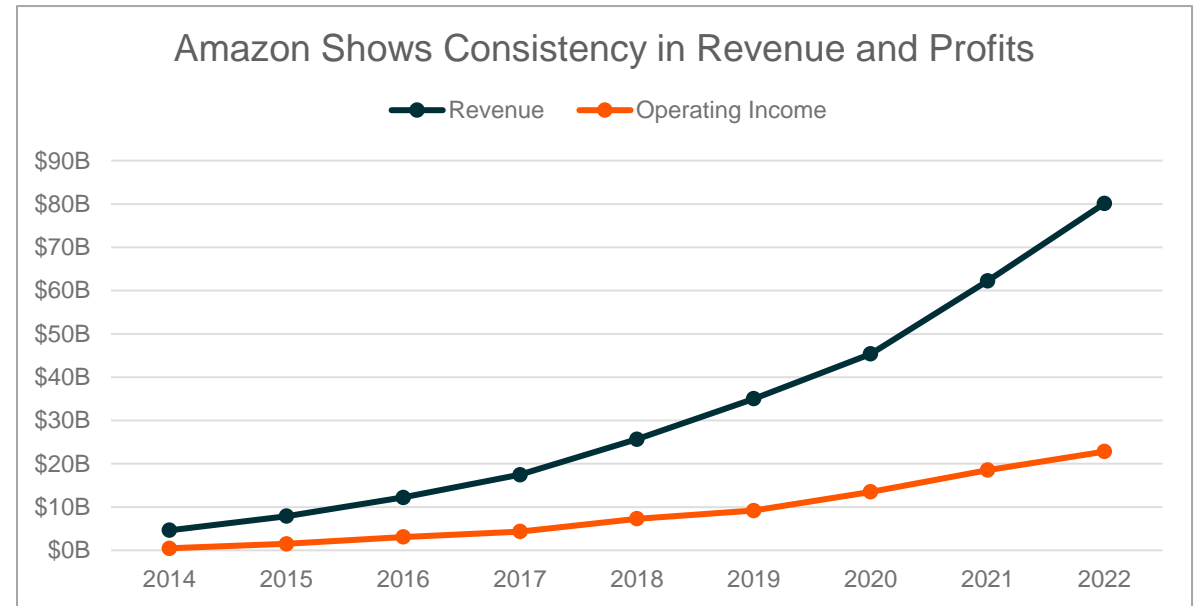
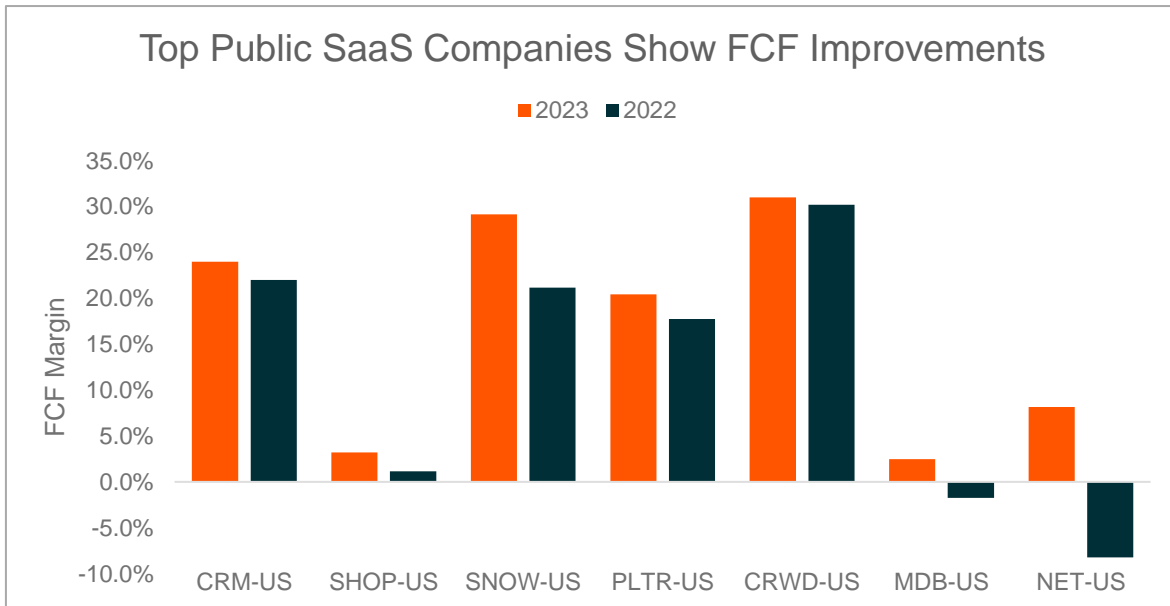
Sources: Gartner, 2023; International Data Corporation (IDC), 2023; Weatherly Asset Management, 2022

Cloud Computing Entered an Optimization Phase in 2022–2023

Rising interest rates and an IT slowdown forced cloud giants to be resourceful and improve fundamentals. Bottom-line efficiency achieved in the recent past will help deliver an outsized boost to profitability in 2024 and beyond.

As cost of capital increased over the past 24 months, cloud computing companies focused on improving bottom-line performance. SaaS companies improved free cash flows (FCFs), with an average of 350bp improvement in the last 12 months.¹

Hyperscalers' margin structures indicate that the businesses can produce steady margins and profits at scale. Market leader Amazon Web Services totaled over \$80 billion in operating profits over the past 10 years.²



Note: Left Chart: 2023 = August 31, 2022 – August 31, 2023; 2022 = August 31, 2021 – August 31, 2022

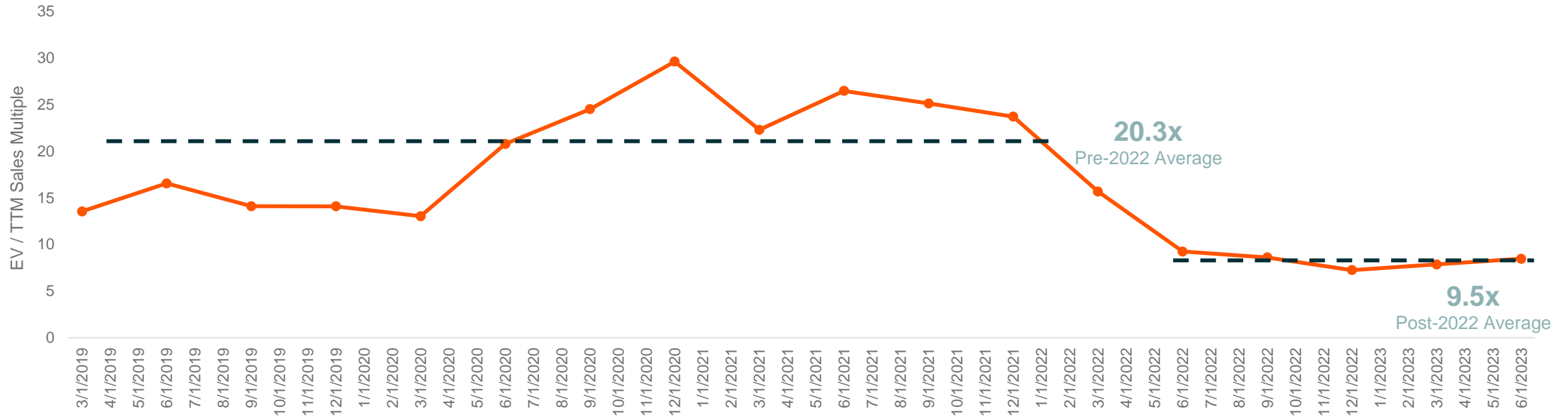
Sources: Text: 1. Factset Research Systems, n.d.; 2. Amazon Investor Relations, 2023; Charts: Left: FactSet Research Systems, 2023; Right: Amazon Investor Relations, 2023; FactSet Research Systems, 2023

Higher Interest Rates Pushed Cloud Computing Valuation Multiples to Historic Lows

Rising interest rates disfavored high-growth software stocks, despite cloud adoption humming along through 2022. Lower multiples present an interesting entry point, as fundamental improvements continue unabated.

Rising Rates Dropped Multiples for Cloud Computing Companies to Historic Lows, Despite Fundamental Improvements

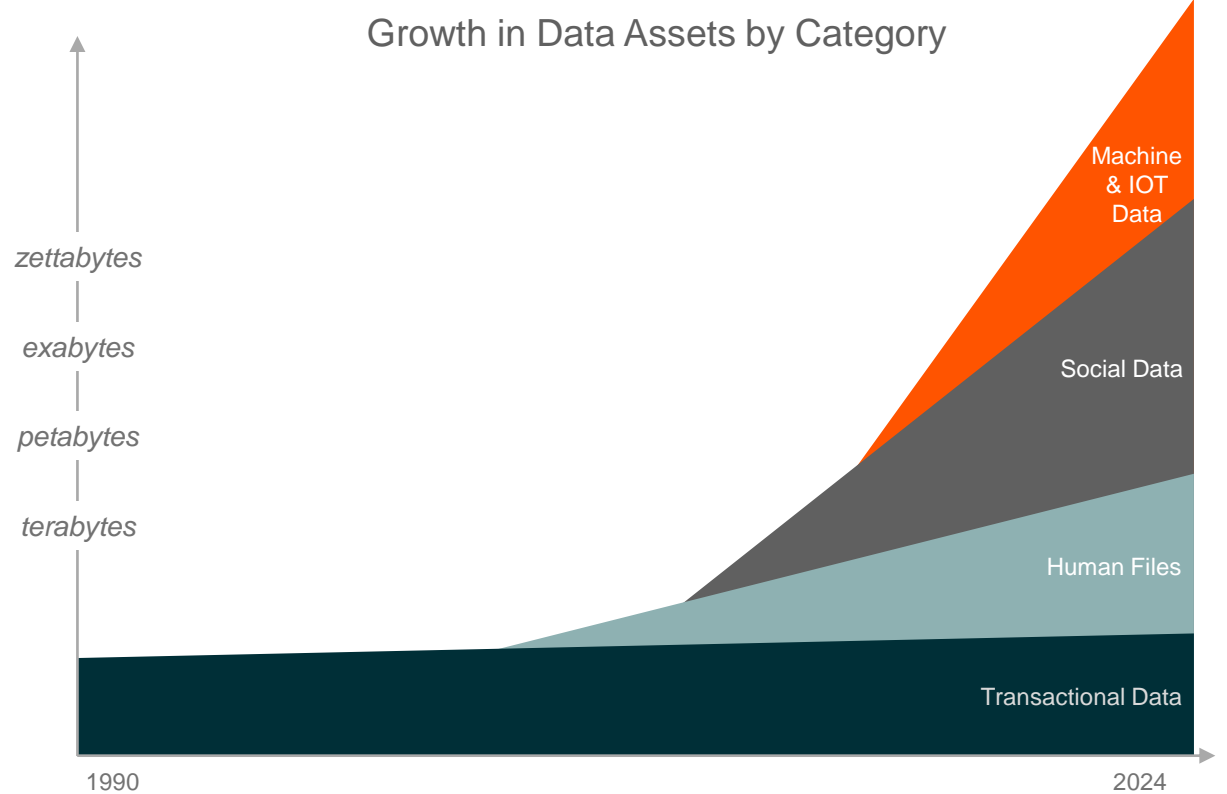
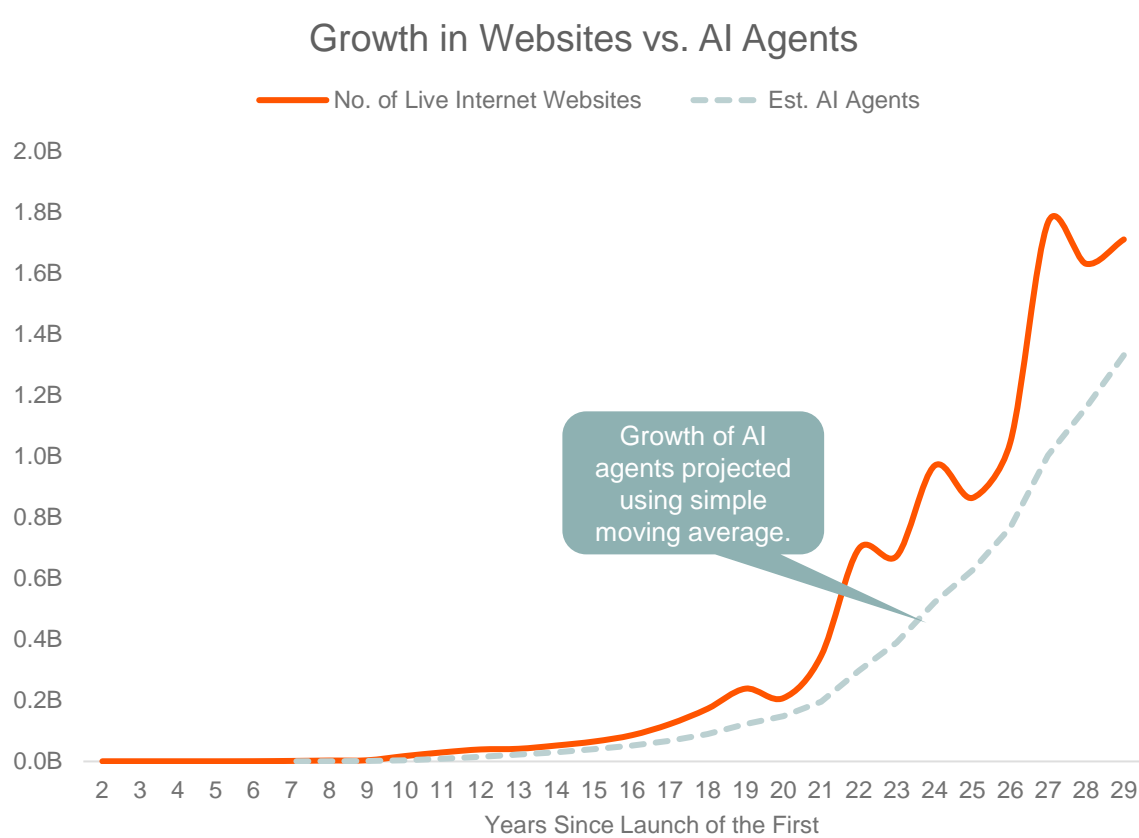
Enterprise Value (EV) to Trailing-Twelve-Months (TTM) Sales Ratio for Cloud Computing SaaS Stocks



Sources: Meritech Capital, n.d.

More Cloud Resources Needed as Data Continues to Explode

The proliferation of AI is likely to shift data creation dynamics, perhaps permanently. By 2030, AI could drive more than half of all online data creation.¹

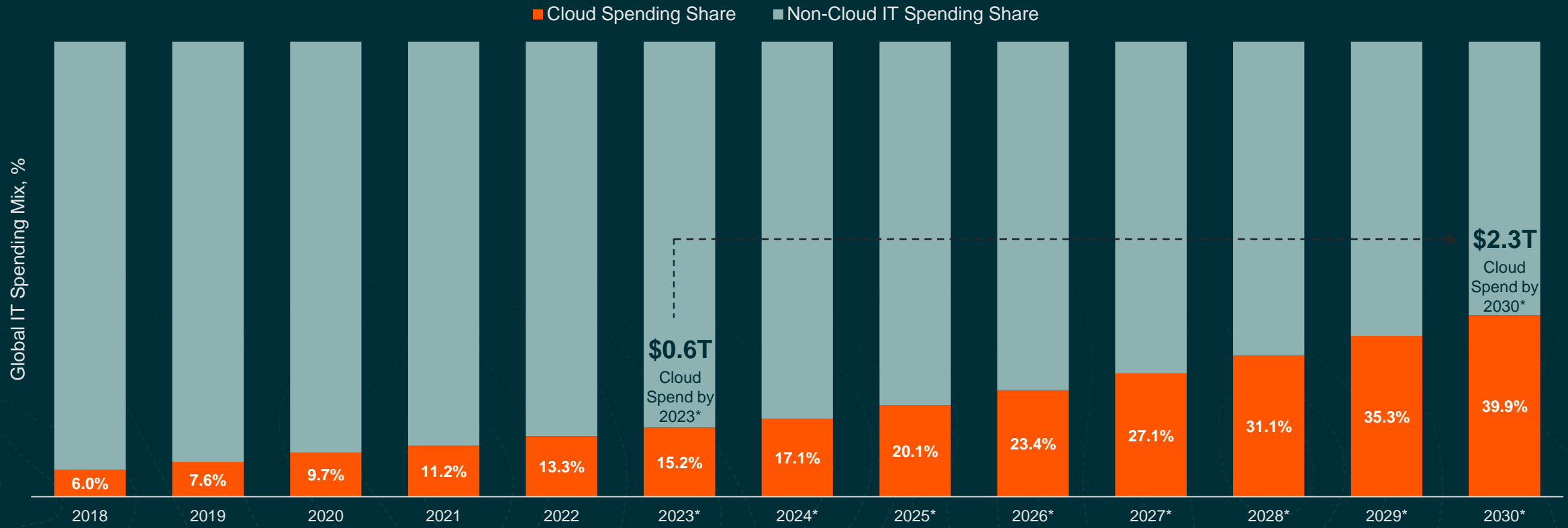


Note: For left chart, Est. AI Agents trajectory is projected using 5-year moving average.

Sources: Text: 1. Gartner, 2021; Charts: Left: Internet Live Stats, n.d.; Gartner, 2021; Right: Exploding Topics, 2023; TechJury, 2023

Investments in AI Primed to Accelerate On-Premise to Cloud Transition

In the current economic climate where cost savings are highly valued, the flexibility and turnkey nature of the cloud model is increasingly important. Spending on AI-related technology is likely to boost cloud's share of IT spend.



* Forecast

Sources: Gartner, 2022; Gartner, 2023

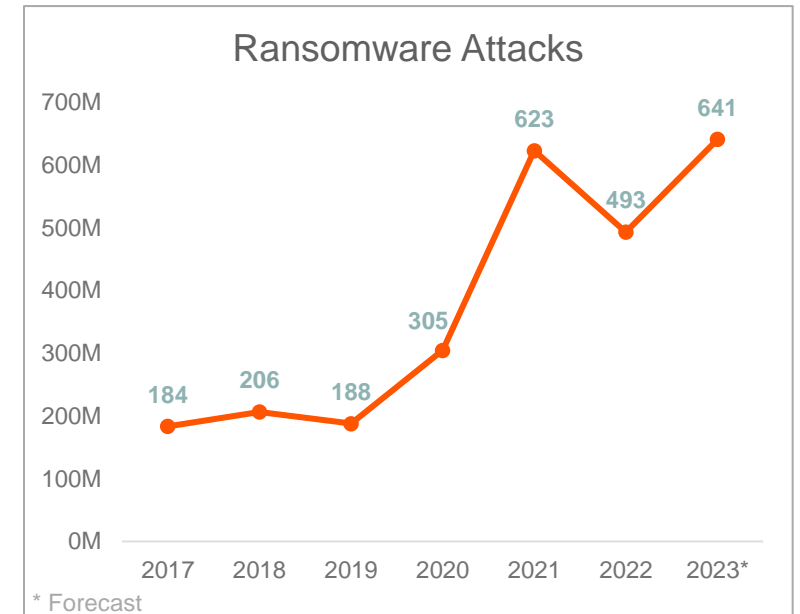
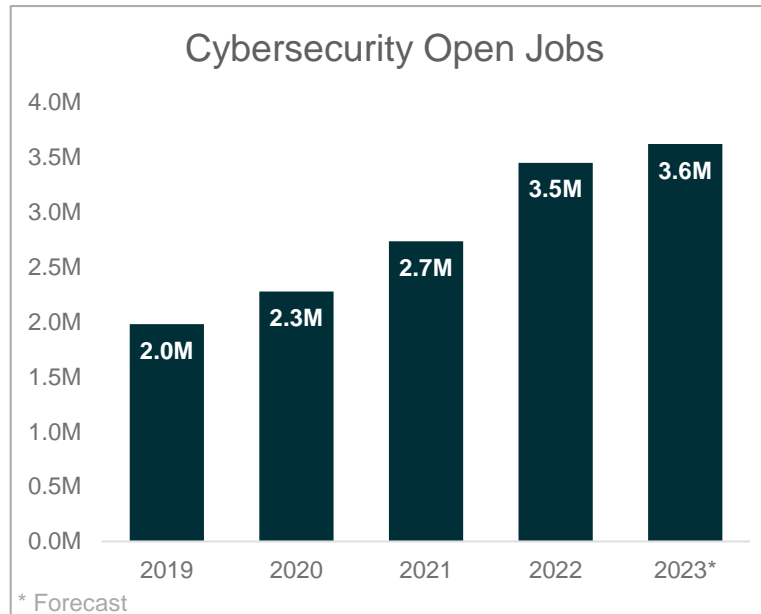
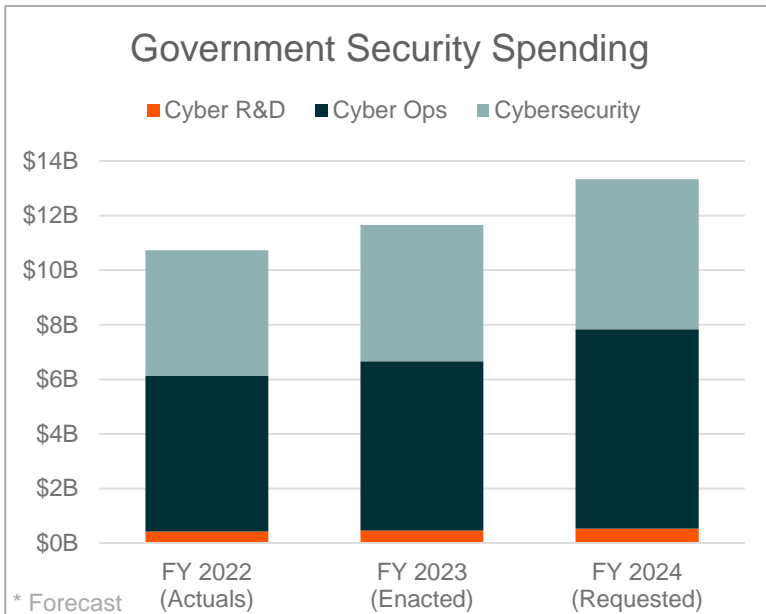
Mounting Cybersecurity Challenges Benefit Cloud-Native Solution Providers

Security teams continue to struggle with rising cyber threats and inefficient operations. Industry demands standardization, and spending on security software will continue to favor cloud-native solutions.

Government priority: Cybersecurity now attracts billions of dollars in spending at the national, state, and local levels. Stricter regulations is also a major focus.

Cyber skill gap: There are 3.6 million unfilled cybersecurity jobs worldwide.¹ This skill deficit affects incident response times and increases vulnerability.

Growing attacks: Ransomware attacks increased 37% in 2023.² Loosely digitized during the pandemic, healthcare and education institutions were primary targets.

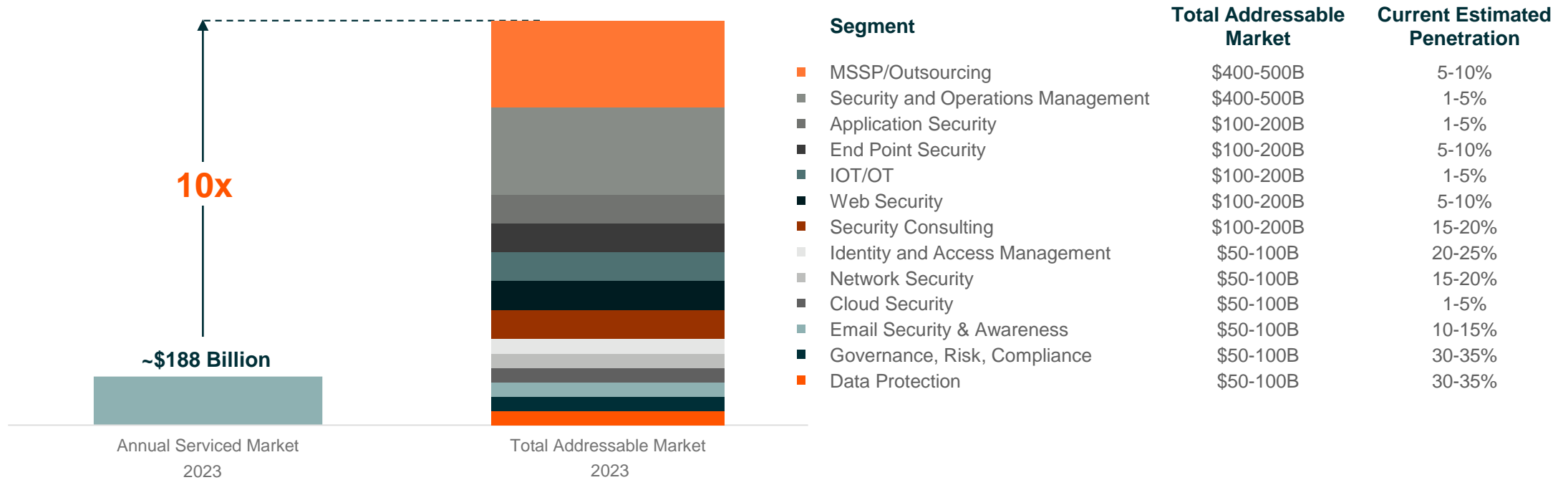


Sources: Text: 1. Cybersecurity Ventures, 2023; 2. Zscaler, Threatlabz Industry Report on Ransomware, 2023; Charts: Left: Security Intelligence, 2023; Middle: Cybersecurity Ventures, 2023; Left: Zscaler, 2023

Industry Fragmentation Favors Cloud-Native Solutions and Large Security Vendors

Cybersecurity markets display extreme fragmentation with nearly 50% of all security spending going to custom and inefficient security services.¹ This dynamic creates opportunities for leading cloud platforms.

Cybersecurity Total Addressable Market Projected to Be Nearly 10x the Total Current Spending on Cybersecurity Solutions

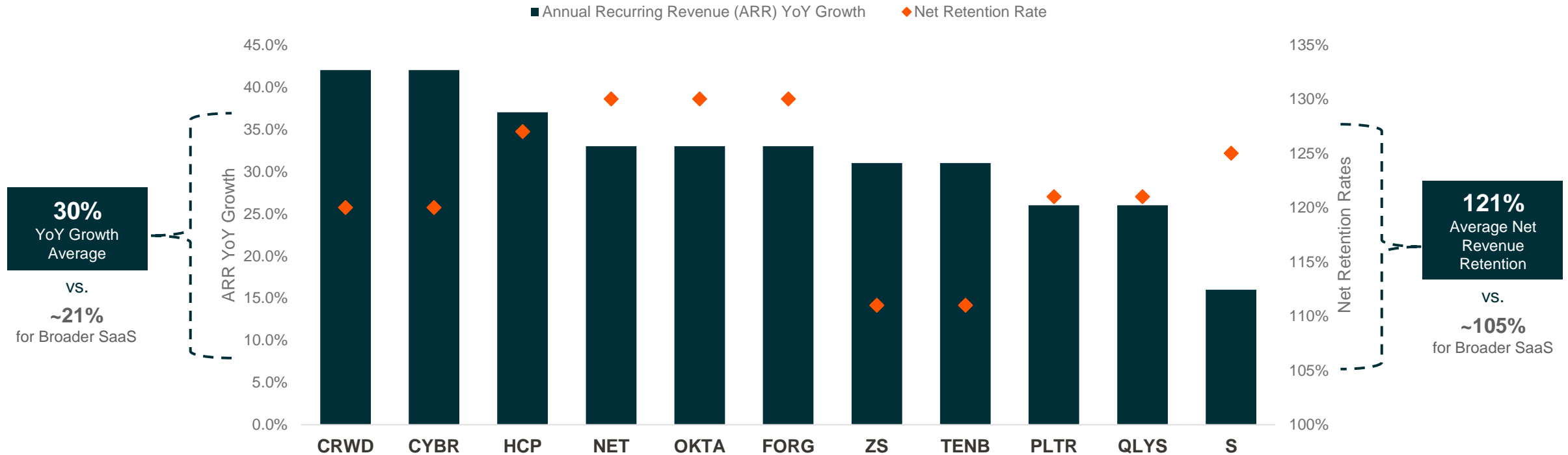


Source: Text: 1. Mckinsey Research, 2022; Charts: Mckinsey Research, 2022

Cybersecurity Is Stickier and Offers a Better Growth Profile Than Broader Cloud Software

The critical nature of software coupled with consumption-based business models results in strong recurring growth for cybersecurity companies, beating broader cloud software standards.

Average Sales Growth and Net Retention for Cybersecurity Companies Is Higher Than the Broader SaaS Cohort



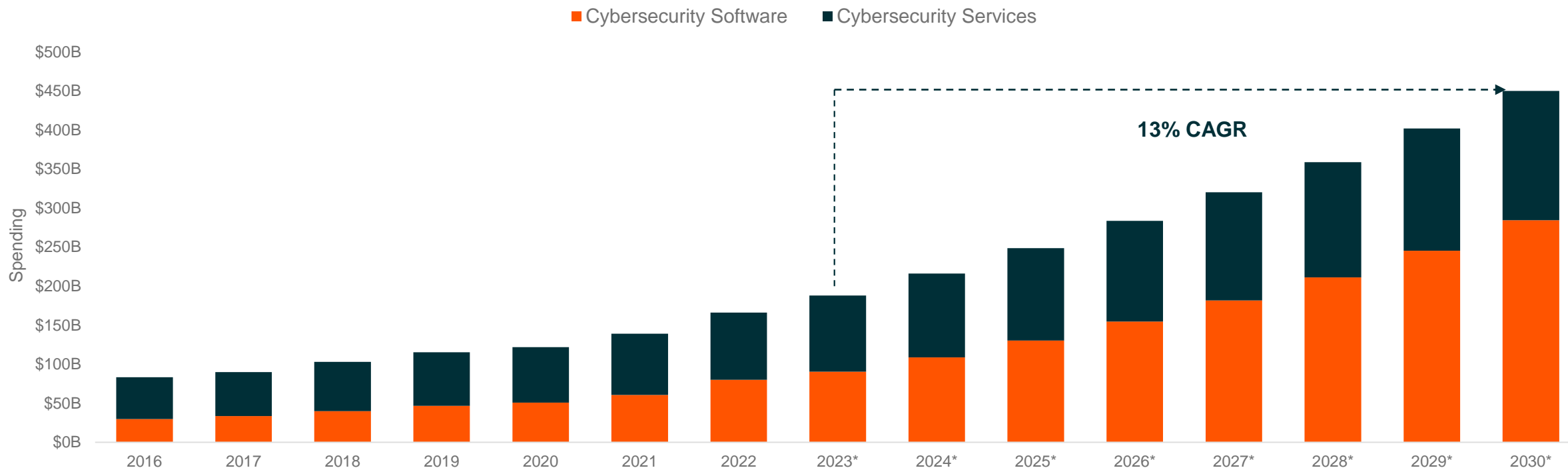
Note: Broader SaaS indicates non-security cloud companies in Meritech Capital Cloud Applications Database. CRWD = CrowdStrike, CYBR = CyberArk, HCP = Hashi Corp, FORG = ForgeRock, NET = Cloudflare, OKTA = Okta, ZS = Scaler, TENB = Tenable Holdings, PLTR = Palantir, QLYS = Qualys, S = Sentinel One.

Sources: Meritech Capital, n.d.

Software Solutions Forecast to Help Cybersecurity Spending Grow 2.5x to \$450 Billion by 2030¹

Cloud-native security solutions allow a broad range of enterprises to phase out custom security solutions and adopt best-of-breed software.

Cloud Software Spending for Cybersecurity Expected to Outpace Spending for Security Services

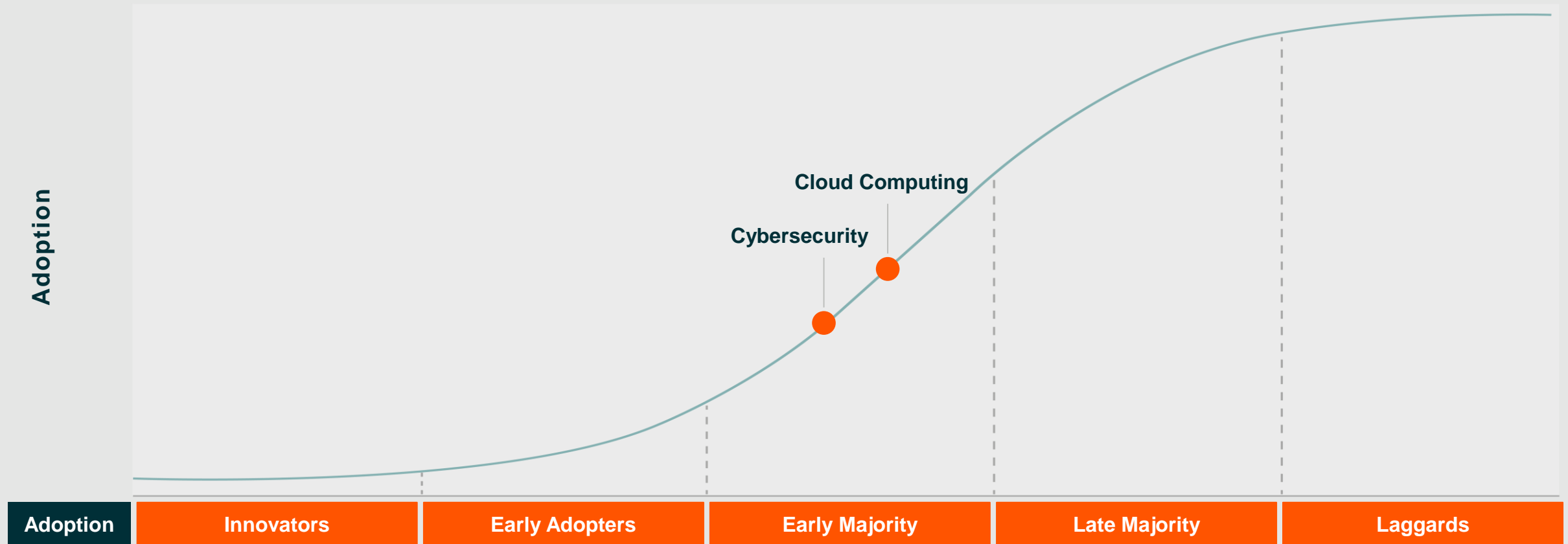


* Forecast

Source: Text: 1. Global X Estimate with data from Gartner 2023, Gartner Forecasts Global Security and Risk Management Spending to Grow 14% in 2024; 2. Gartner, 2022; Chart Source: Gartner, (2023, Sep 28). Gartner Forecasts Global Security and Risk Management Spending to Grow 14% in 2024

Cloud Computing: S-Shaped Curve of Adoption

Cloud computing is expected to generate revenues of \$600 billion in 2023, up 21% YoY.¹



Note: For illustrative purposes only.

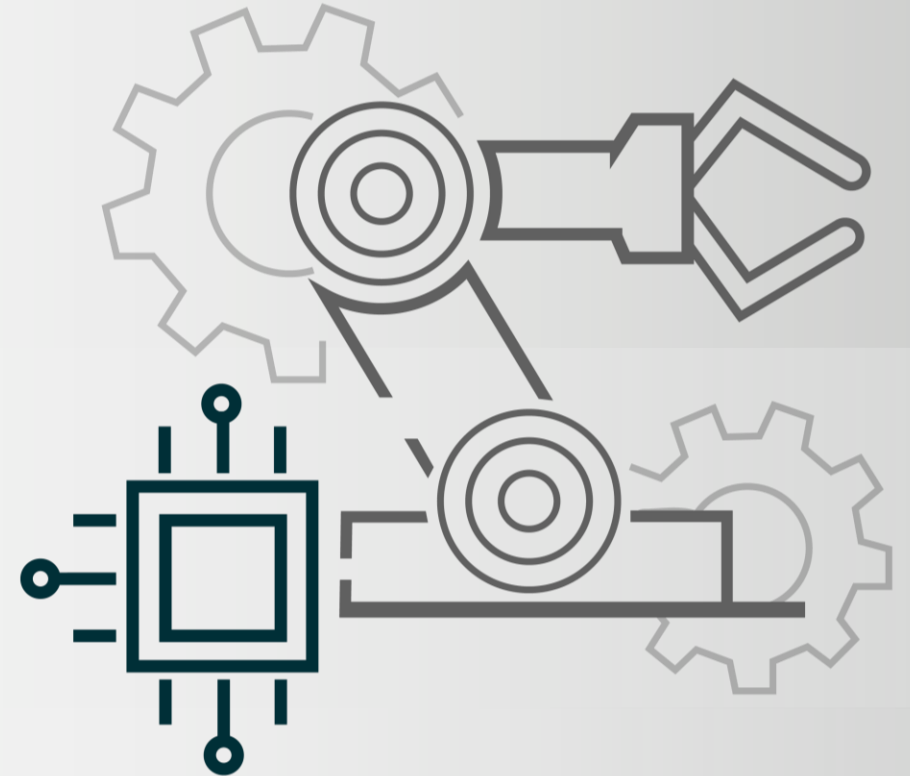
Sources: Text: 1 Gartner, 2023

Paradigm-Shifting Technologies

Robotics

The Rise of Smart Machines

Industrial robotic installations are at record highs and we anticipate that robots in the service industry, particularly those used in delivery and healthcare, will continue to expand their market share due to advancements in technologies like generative artificial intelligence (AI). Concurrently, the reshoring trend in manufacturing and industrial operations necessitates substantial investments in infrastructure and technology. Robotics systems will be instrumental in these transitions, being poised to enhance quality, lower costs, and enable businesses to maintain global competitiveness.

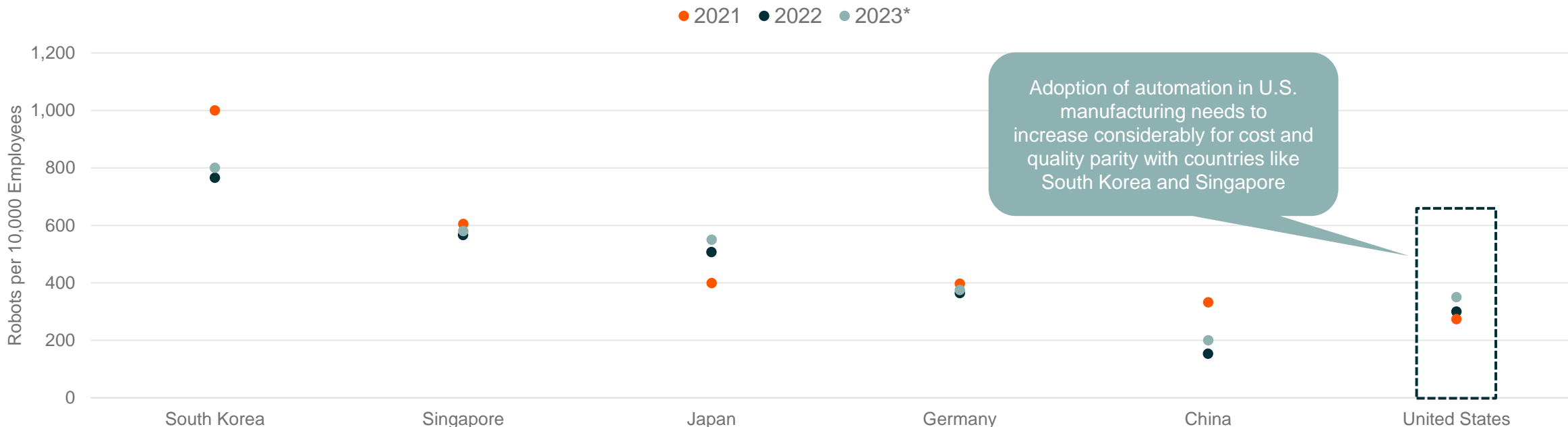


Reshoring of Manufacturing Is Not Possible Without Adoption of Automation

As automation becomes more widely available, offshoring manufacturing operations overseas may no longer be more affordable. Automation will play a key role in allowing U.S. businesses to stay competitive on the global stage.

Top Five Markets with the Highest Robot Densities in 2022: South Korea, Singapore, Japan, Germany, and the United States ¹

Robots per 10,000 Employees in Manufacturing



* Forecast.

Note: U.S. numbers for 2022 are Global X ETFs estimates based on sources below

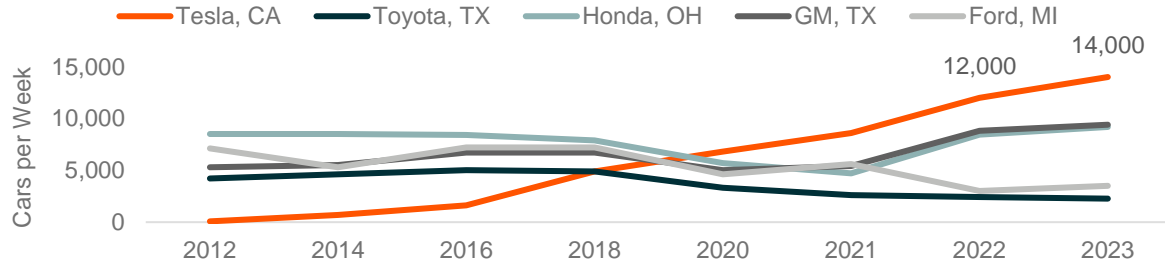
Sources: Text: 1. RobotIQ, 2023; Chart: International Federation of Robotics, 2022; RobotIQ, 2023

Tesla Case Study: Robotic-Heavy Auto Manufacturers Outperform Traditional OEMs in Efficiency

By strategically investing in robotics and AI over human capital, manufacturers can achieve significant productivity gains. Tesla's implementation of these technologies enabled it to increase output while curtailing labor hours.

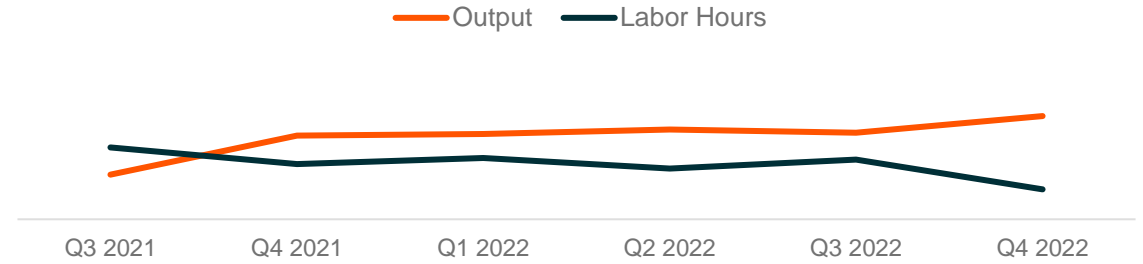
Tesla's Fremont, CA Factory Led EV Auto Production in 2022

Average Weekly Output by Year and Factory

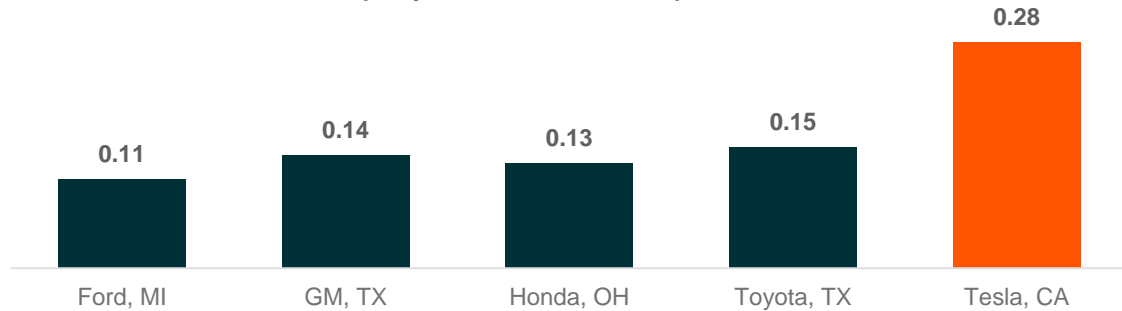


Tesla's Labor Hours Drop as Its Production Facilities Mature

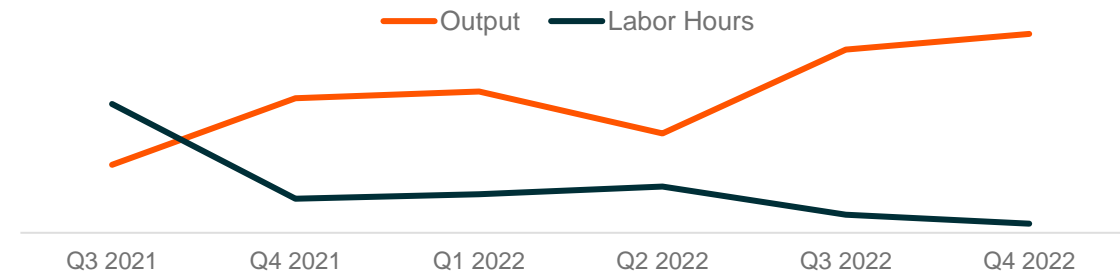
Tesla Fremont



Robot to Employee Ratio for Top U.S. Automakers



Tesla Shanghai



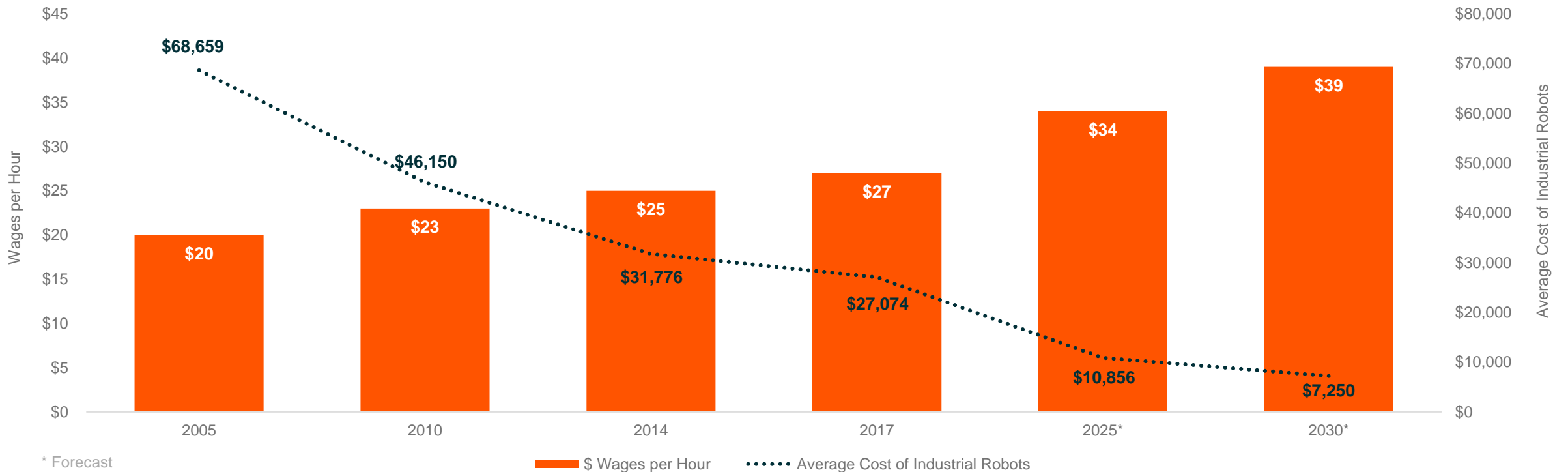
Note: OEM = Original Equipment Manufacturer; EV = Electric Vehicles; 2023 data in Average Weekly Output by Year and Factory is a Global X ETFs estimate

Sources: Charts: Left Top and Bottom: The Washington Post, 2016; Bloomberg, 2022; Toyota, 2020; Manufacturing Digital Magazine, 2020; Wired, 2013; Tesmanian, 2022; Right Top and Bottom: Tesla, 2023

Lower Costs and Higher Precision Drive Adoption of Robotic Systems Across Industries

As industrial robots become more affordable and technologically sophisticated, their adoption will increase across various industries, especially as companies look for ways to improve efficiency and productivity.

Manufacturing Wages vs. Average Cost of Industrial Robots

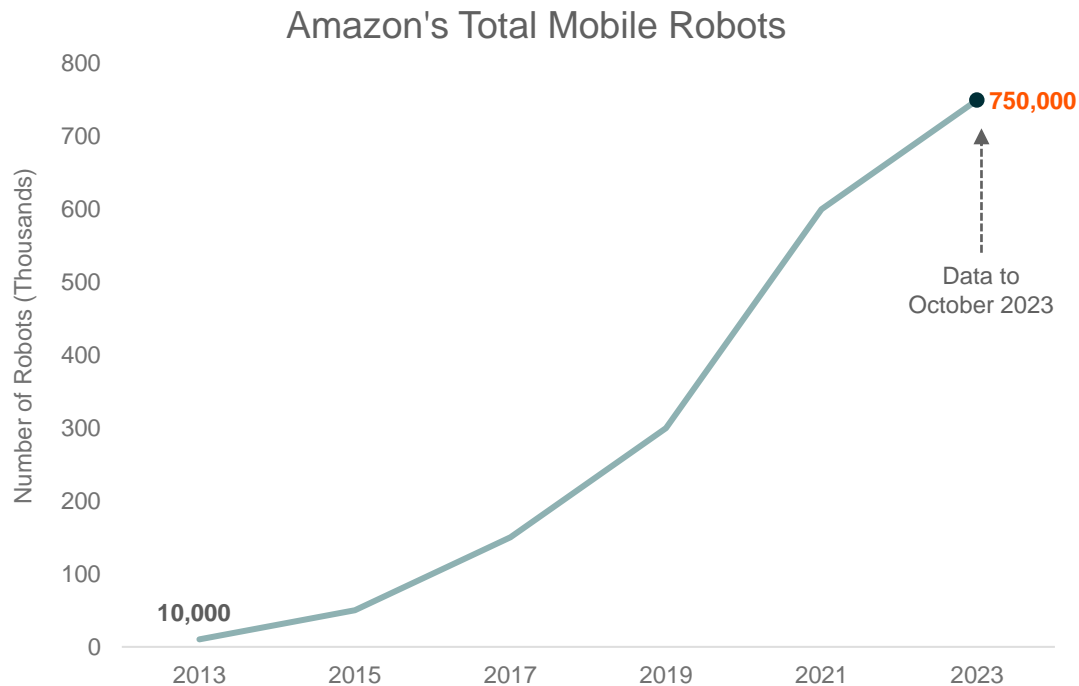


Sources: U.S. Bureau of Labor Statistics, 2023; Munich Personal RePEc Archive, 2021

Novel Patents and Innovations Generating Cross-Industry Adoption

Robotics and AI innovation is being prioritized across diversified key segments spanning e-commerce, healthcare, and agriculture, further evidenced by patent activity.¹

Amazon Rapidly Increased Production of the Robots It Uses in Its Warehouses



Field Testing

Proteus & Cardinal

Amazon is testing the joint operation of its Proteus and Cardinal robotics systems. The Cardinal system loads packages bound for the same zip code into designated carts. Proteus robots then bring the carts to delivery trucks, smoothly navigating the outbound dock area while working alongside human staff.



Sparrow

Sparrow selects and categorizes numerous customer orders, effectively testing its ability to manage highly repetitive tasks. Recent progress in computer vision, machine learning, and AI facilitates achievements that were not possible just a short time ago.



Containerized Storage

Amazon's new Containerized Storage System uses robotics and software to ensure employee safety and efficiency. It determines the right container, its location, and guides its retrieval and pick-up by employees.

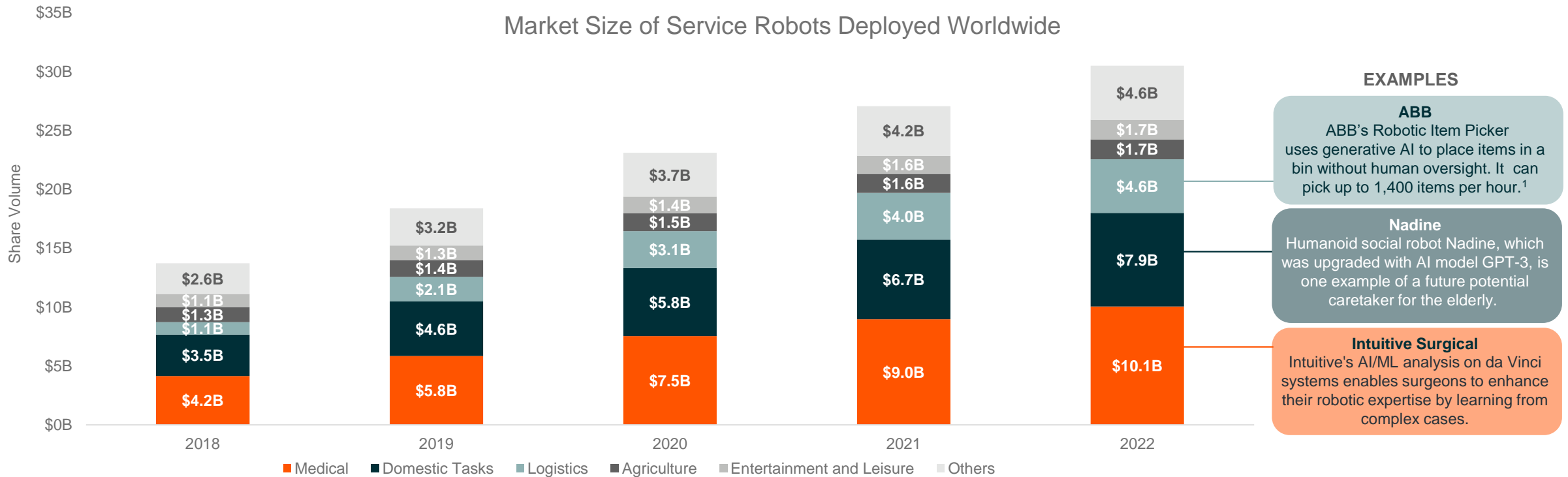


Sources: Text: 1. GlobalData, 2022; Chart: Wired, 2023

Service Industry Robotics Positioned to Receive a Boost from Generative AI

AI can revolutionize the robotics industry through personalization, with generative AI being key. Synthetic scenarios can facilitate reinforcement learning in simulations, allowing robots to acquire novel behaviors.

Progress in AI, Advancements in Systems Engineering, and High Labor Costs Are Boosting the Service Robotics Market



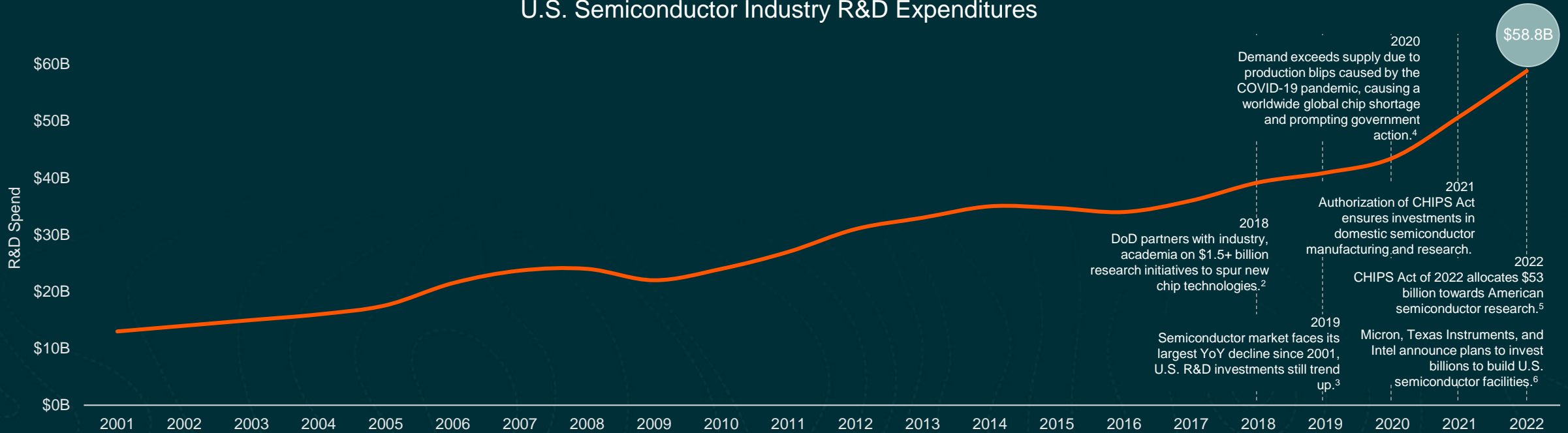
Sources: Text: 1. ABB, 2023; Chart: IFR Pressroom, 2022

U.S. Chip Manufacturing Programs Are Tailwinds for Automation

Over 50 projects totaling \$210 billion in semiconductor manufacturing investment commitments have been announced across 20 states since May 2020.¹

R&D Spending from U.S. Semiconductor Companies Remains High, Irrespective of Fluctuations in Sales Trends

U.S. Semiconductor Industry R&D Expenditures



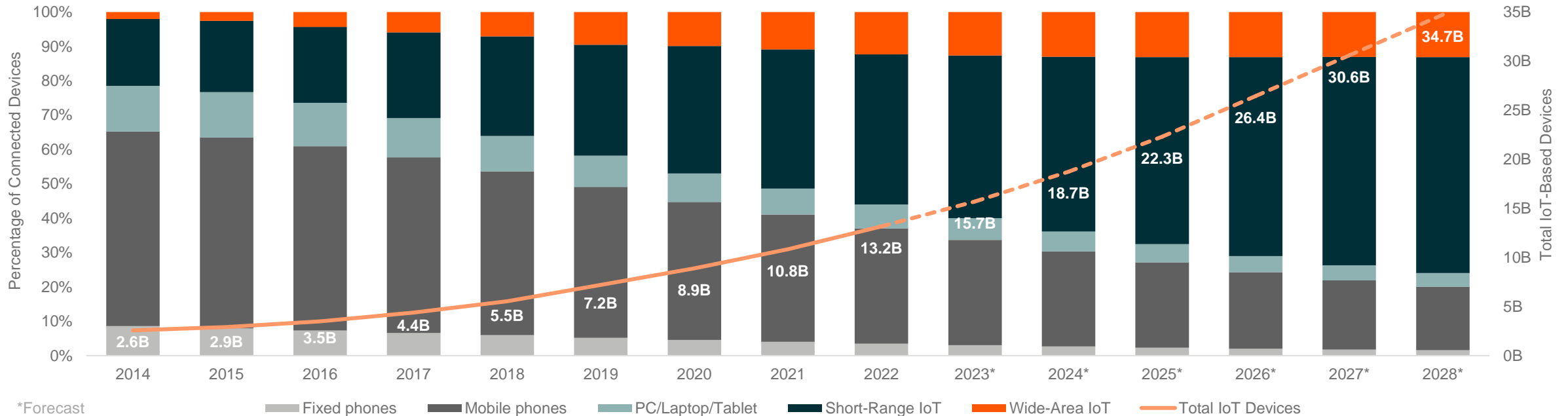
Sources: Text: 1. Semiconductor Industry Association, 2023; 2. Semiconductor Industry Association, 2021; 3. Electronic Specifier, 2019; 4. Semiconductor Industry Association, 2021; 5. The White House, 2022; 6. Tom's Hardware, 2022; Chart: Semiconductor Industry Association, 2023

Automation and Digitization of Operational Technology on Track to Boost IoT Adoption

In the rapidly evolving landscape of technology and connectivity, the proliferation of Internet of Things (IoT) devices is poised to reach unprecedented heights.

Global IoT Devices Are Expected to Top 15.7 Billion in 2023 and More Than Double from There by 2028

Global Connected Device Mix and IoT Installed Base



Note: Connected devices classified within IoT include items such as wearables, machines, sensors, connected cars, and more. These devices are further classified into Short-Range IoT and Wide-Area IoT based on connectivity range.





Sources: Ericsson, n.d.

Autonomous Vehicles (AVs) Are Expanding Their Commercial Footprints

While AVs are not available for purchase yet, driverless commercial vehicles are operational. Robo-taxis are witnessing a phased, geo-fenced launch nationwide, while major investments continue to fund autonomous trucking.




Robo-Taxi Offerings Already Hitting the Road



Company	Fully Driverless Offering Release*	Where is it Available?
 Google's Waymo ¹	October 2020	Metro Phoenix, San Francisco, and ramping up in LA and Austin
 AutoX ²	January 2021	Silicon Valley, Shenzhen, Shanghai, Guangzhou, and Beijing
 Baidu's Apollo Go ³	May 2021	Beijing, Wuhan, Chongqing, Shanghai, and Shenzhen
 GM's Cruise ⁴	November 2021	San Francisco, Austin, Phoenix, and Houston

Fully Driverless Truck Deliveries on the Way



Company	Expected Commercial Launch*	Where Could it be Available?
 Kodiak Robotics ⁵	2024	Texas, Oklahoma, and other Southern States
 Aurora ⁶	2024	Texas
 TuSimple ⁷	2025	Arizona

Note: Fully driverless offerings already released and expected commercial launches are only in selected cities. For example, Cruise and Waymo both currently operate in San Francisco and Phoenix, and both companies have ambitious expansion plans with test sites in Southern California, Texas, Nashville, Miami, and beyond.

Sources: Text: 1. White, 2020; 2. Crowe, 2021; 3. Baidu, Inc., 2021; 4. Bellan, 2021; 5. Taube, 2023; 6. Tilton, 2023; 7. TuSimple, 2023

Autonomous Trucks: Plug-and-Play Technology to Accelerate Adoption

Don Burnette

AVs use advanced sensor technologies such as LiDAR, radar, and cameras, along with powerful computing systems driven by AI. Kodiak's latest SensorPods replace a truck's mirrors with a compact package of these technologies.

Kodiak's Trucks Use Eight Cameras, as well as Four Radar and LiDAR Units

Cameras:

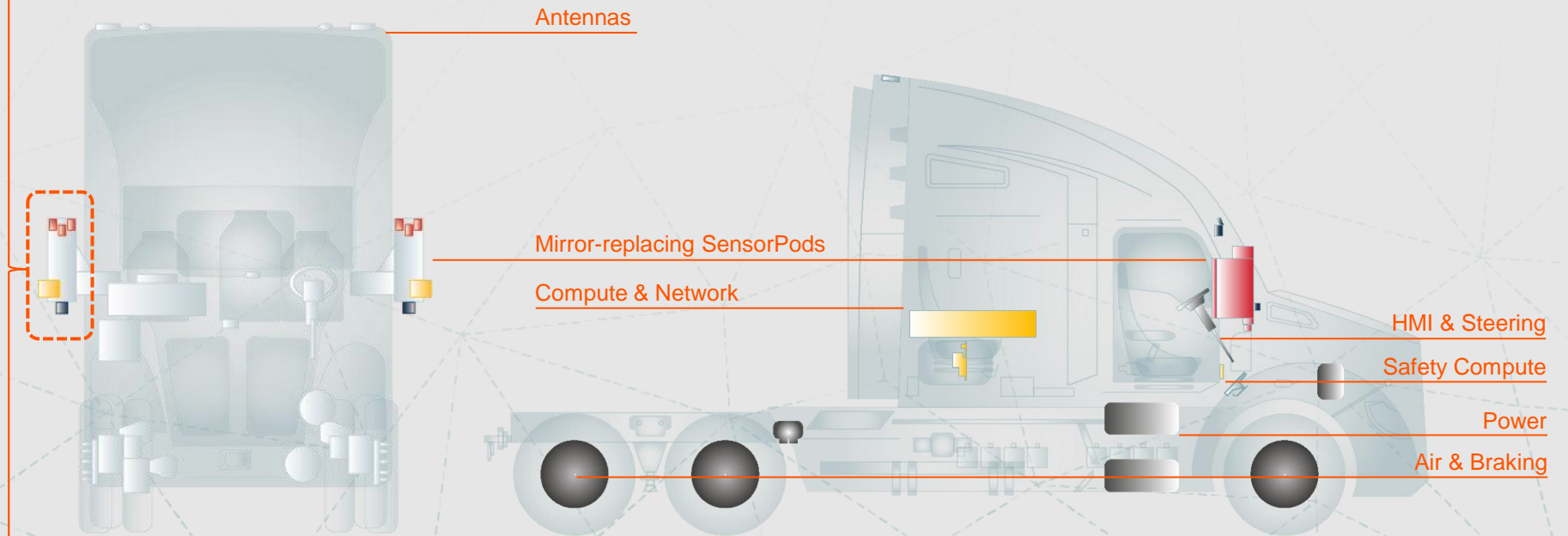
1. Cost-effective and widely available.
2. High-resolution imaging for detailed visual perception.
3. Efficient in identifying and interpreting traffic signs, signals, and road markings.

LiDAR (Light Detection and Ranging):

1. Precise 3D mapping and spatial awareness.
2. Effective in low-light conditions and at night.
3. Accurate depth perception and object recognition.

Radar:

1. Excellent in detecting the speed and distance of objects.
2. Works well in adverse weather conditions.
3. Robust in identifying and tracking moving objects.

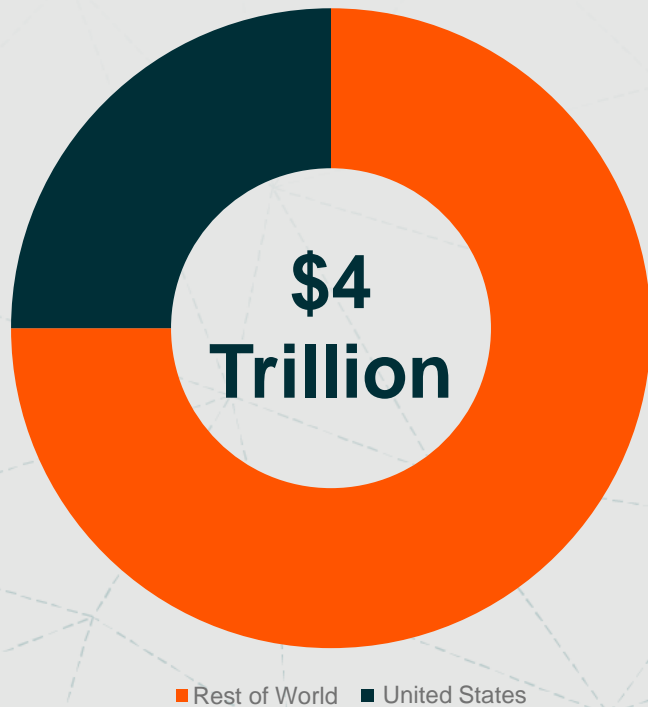


Autonomous Trucks' Market Opportunity

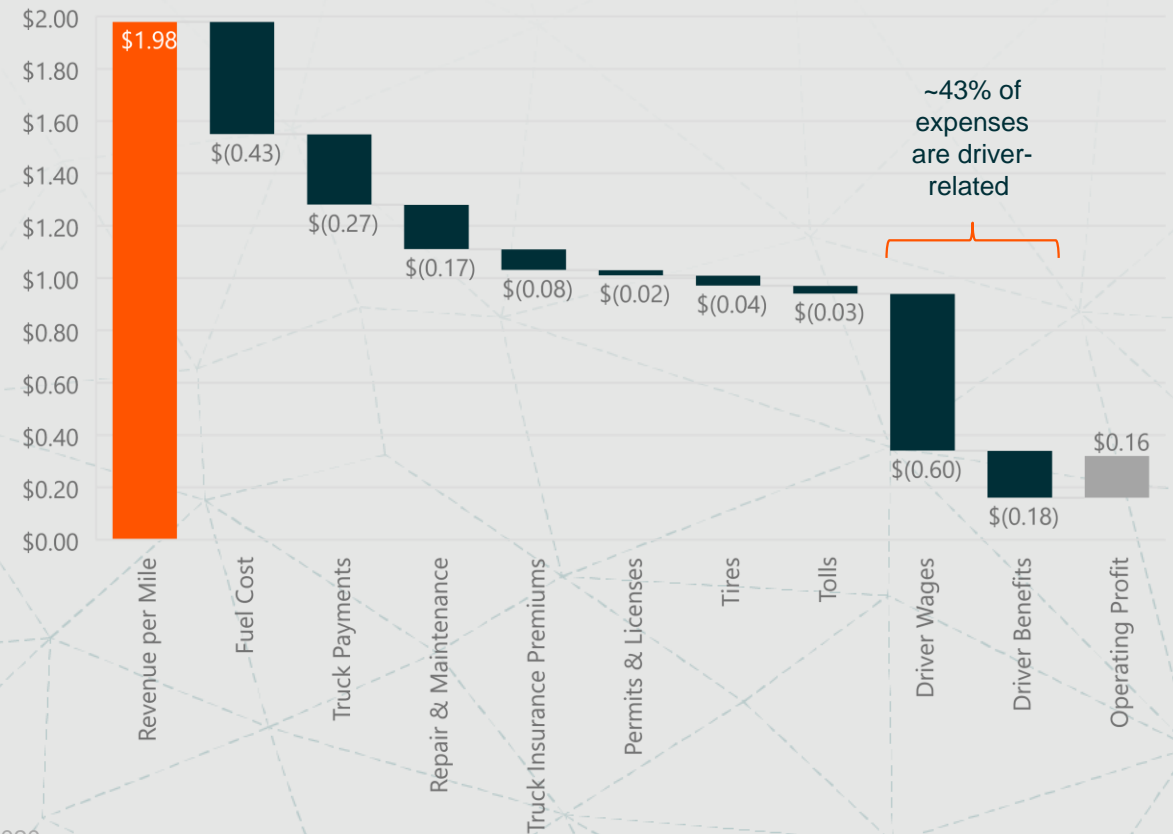
Don Burnette

The global economy relies on trucks. For example, in the United States, trucks accounts for 4% of GDP.¹ In addition, AVs have the potential to increase truck utilization, revenue, and margins, while effectively addressing driver shortages.

Global Trucking Total Addressable Market



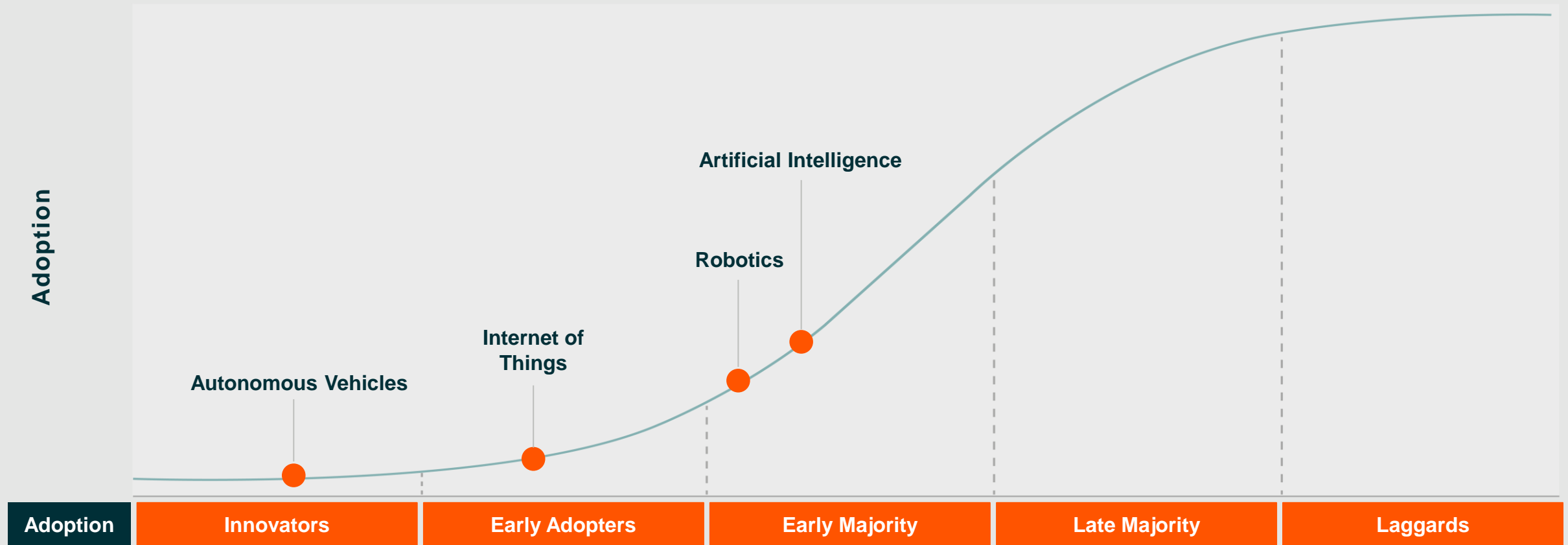
Truckload Carrier's Revenue and Expenses per Mile



Sources: Text: American Trucking Associations, 2023; Charts: Right: J.P. Morgan, 2021; Left: Williams & Murray, 2020

Robotics: S-Shaped Curve of Adoption

The global robotics market is expected to expand to about \$250 billion by 2030, a 22.8% compound annual growth rate (CAGR).¹



Note: For illustrative purposes only.

Sources: Text: 1.Market Research Future, 2023

Paradigm-Shifting Technologies

Clicks & Commerce

What's Next for the Internet Economy

Consumers are dedicating more time and financial resources to online pursuits. In response, platforms are shifting to align with heightened consumer expectations while progressively monetizing their offerings. The appeal of e-commerce remains strong, but there's a noticeable trend as consumers increasingly return to physical stores, catalyzing the digital transformation of brick-and-mortar establishments. In parallel, the expansion of financial technology persists, and platforms catering to the digitization requirements of banks are experiencing sustainable growth.

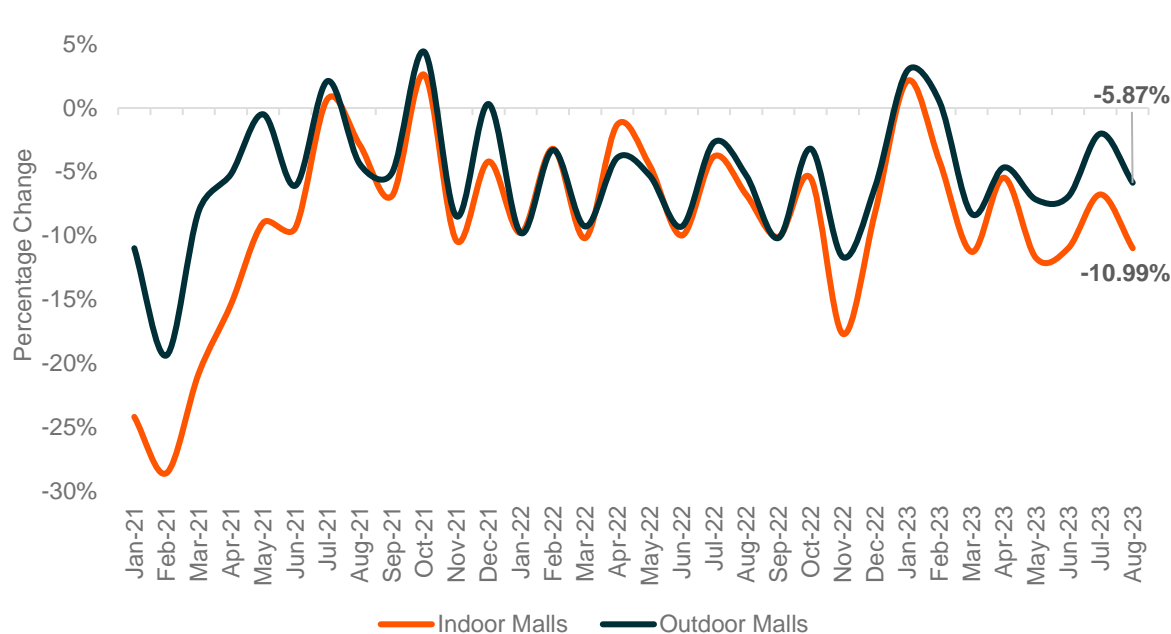


Digitally Equipped Merchants Are Ready for an Omnichannel Future

The brick-and-mortar business remains a critical element for winners in omnichannel. However, a retailer's online presence is an important portal to achieve customer retention in an increasingly digital world.

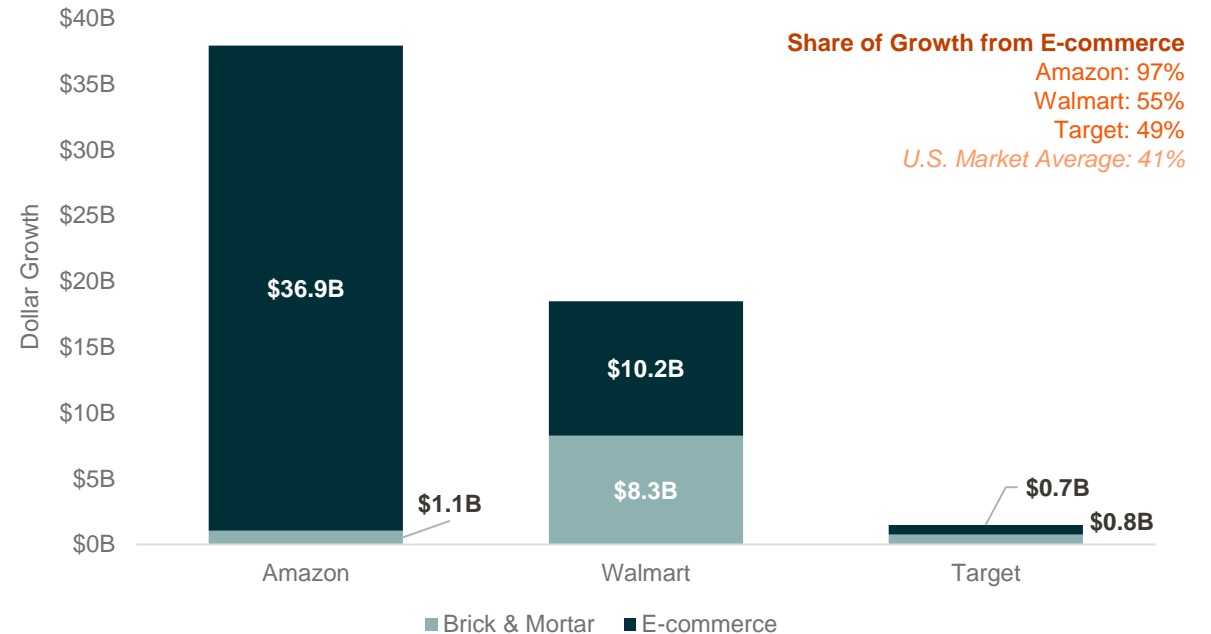
Commercial Foot Traffic Largely Below Pre-COVID Levels

Monthly Foot Traffic in U.S. Malls Relative to 2019



U.S. E-commerce Projected to Take Majority Share

Projected 2023 Revenue Growth of U.S. Retailers



Note: For 2022 and 2023 in LHS chart, Outdoor Malls defined as 'Open-Air Lifestyle Centers.'

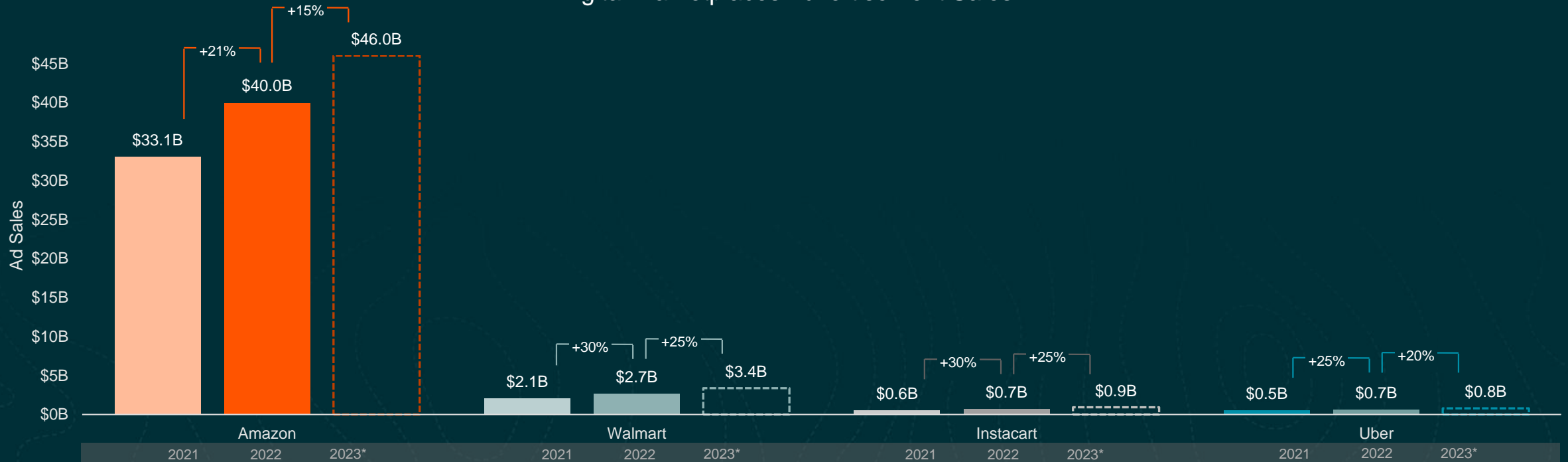
Sources: Charts: Left: Placer.AI, 2023-Sep; Placer.AI, 2023; Right: Stratably, 2023; U.S. Census Bureau, 2023

Digital Retailers and Service Providers Boost Marketplace Profitability Through Advertising

Advertising is a revenue source for top digital marketplace players in e-commerce. Companies like Walmart, Instacart, and Uber embraced ads to capitalize on the benefits of increased sales growth.

Ad Sales Are a Vital Source of Revenue for the Delivery Intermediaries and the Businesses Utilizing Them

Digital Marketplaces Advertisement Sales



* Forecast

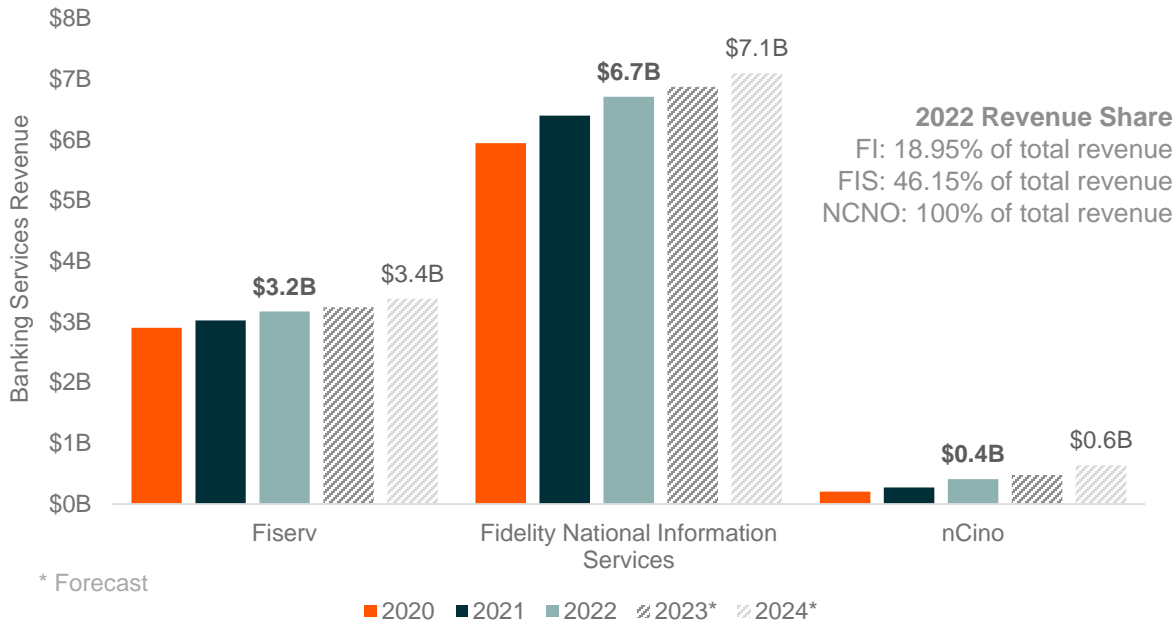
Sources: Amazon, 2022; Amazon, 2023; The Information, 2023; Uber, 2022; Uber, 2023; Walmart, 2022; Walmart, 2023

FinTech Platforms That Help Banks Digitize Their Operations Are Thriving

FinTech infrastructure companies are transforming the industry with application programming interfaces (APIs) that enable banks, and virtually any software company, to offer digital financial products to their customers.

Supplying Infrastructure to Banks Is a Lucrative Business

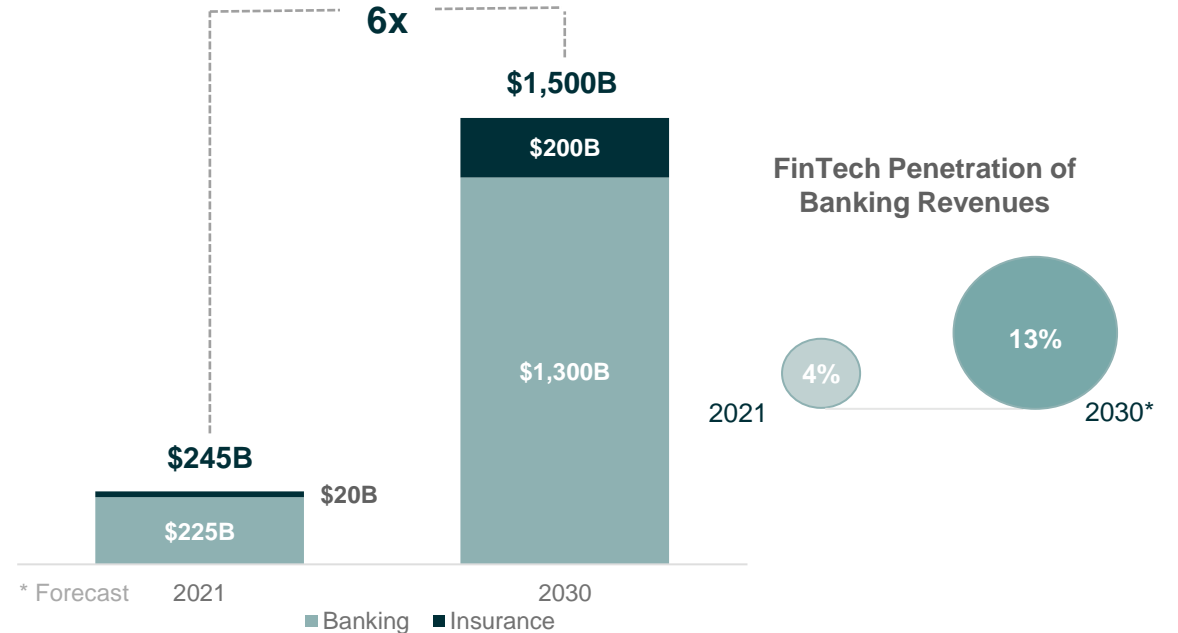
Select FinTechs Revenue Growth from Banking Services



Note: Left Chart, "Banking Services" classified as: Fiserv (FinTech), Fidelity National Information Services (Banking Solutions), nCino (Total). These are based on the category breakdowns provided by FactSet.

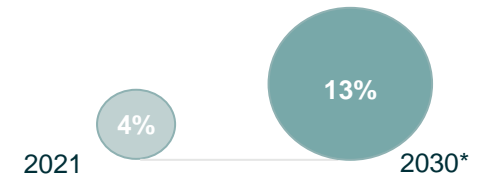
FinTechs Projected to Generate Sizable Banking Revenues

Global FinTech Revenues



Note: Banking FinTech revenues are represented by revenues from lending, deposits, payments, as well as trading and investments.

FinTech Penetration of Banking Revenues



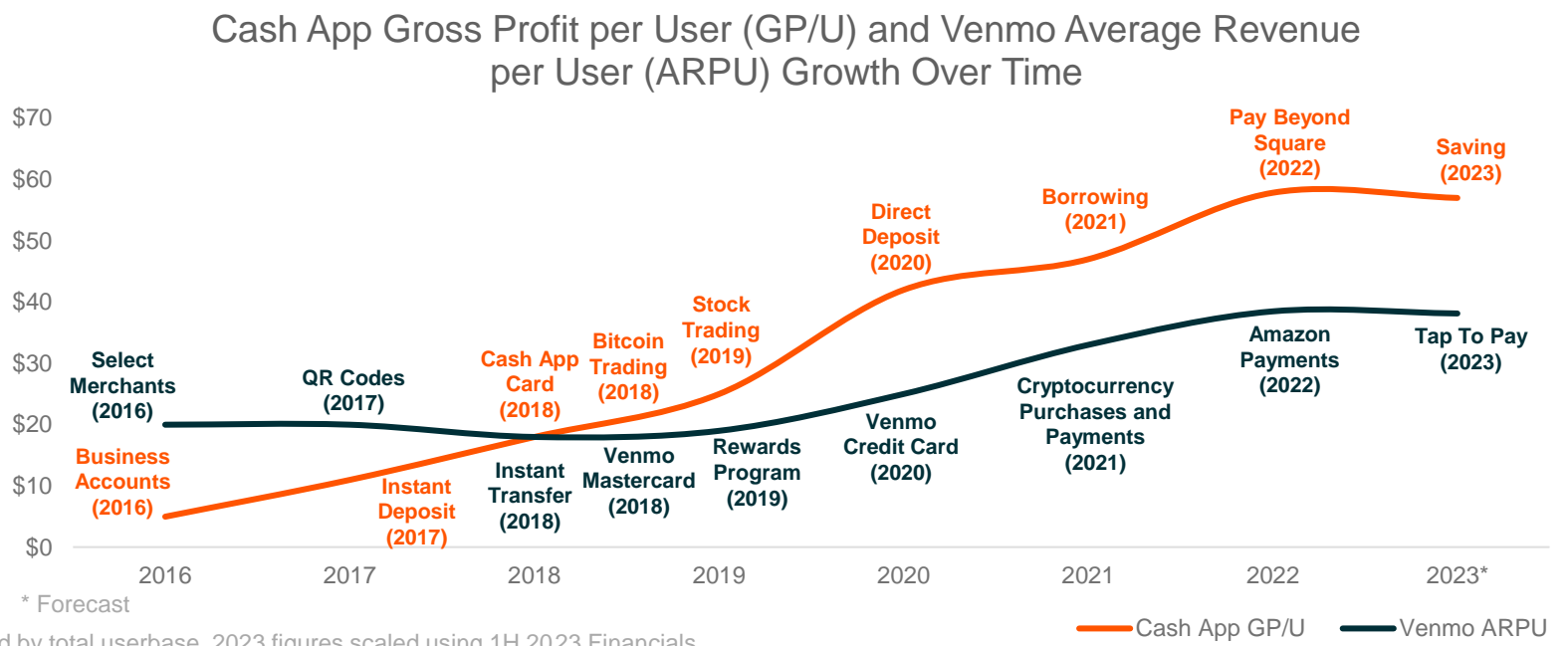
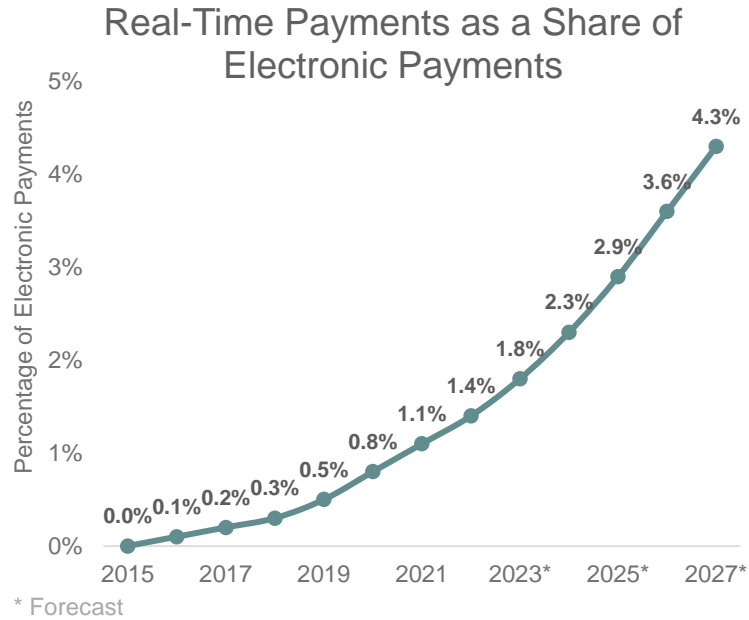
Sources: Left: FactSet Research Systems, n.d.; Right: Boston Consulting Group, 2023

Digital Wallets Are Turning Into Super Apps, Boosting Profitability and Shrinking Costs

There is an uptick in adoption of real-time payments, even relative to increased digitization across the payments industry. Digital wallets like Venmo and Cash App are utilizing this shift to gain on payoff per user.

Real-time payments remain **only a fraction** of all electronic payments, but they're on an **upward trajectory**.

Venmo and Cash App's **freemium models** make them highly scalable. The popular P2P payment platforms' sustainability depends on the power of their **network effects**, not just their functionality. **Value-added services** consistently help new users discover utility in these platforms.



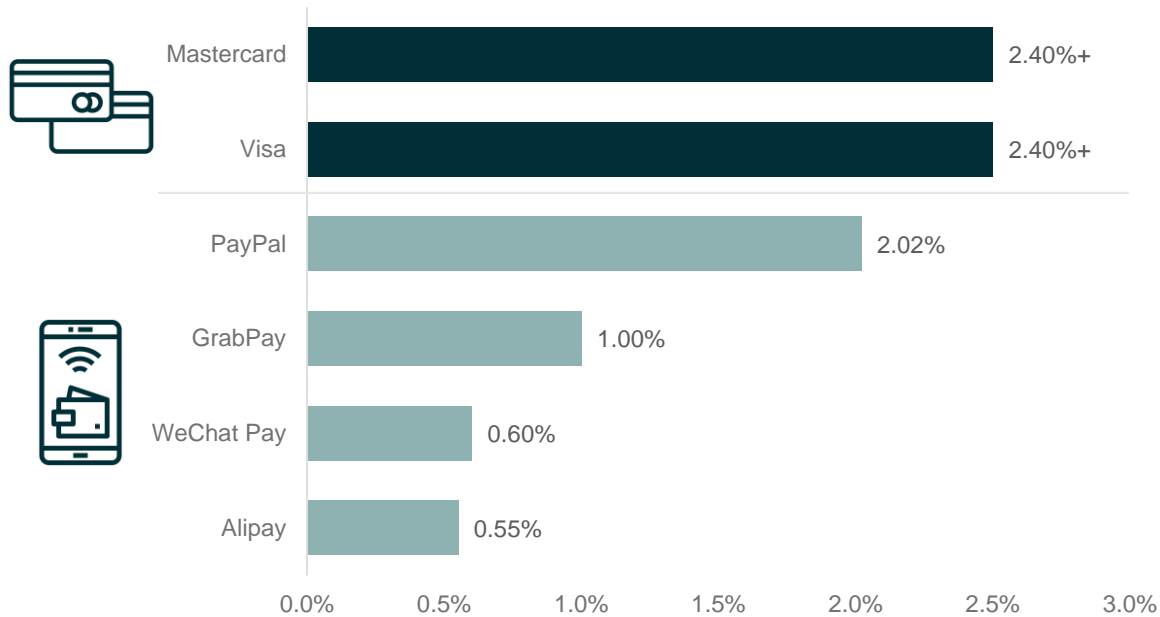
Note: Venmo ARPU calculated using scaled total payment value (TPV) divided by total userbase. 2023 figures scaled using 1H 2023 Financials.

Sources: Charts: Left: ACI Worldwide, 2022; Right: Block Inc., 2023

Global Disruption of Traditional Financial Services Offers Plenty of Opportunity

FinTech industry fundamentals are robust despite the recent challenges and e-wallets continue to gain share, especially in emerging markets.

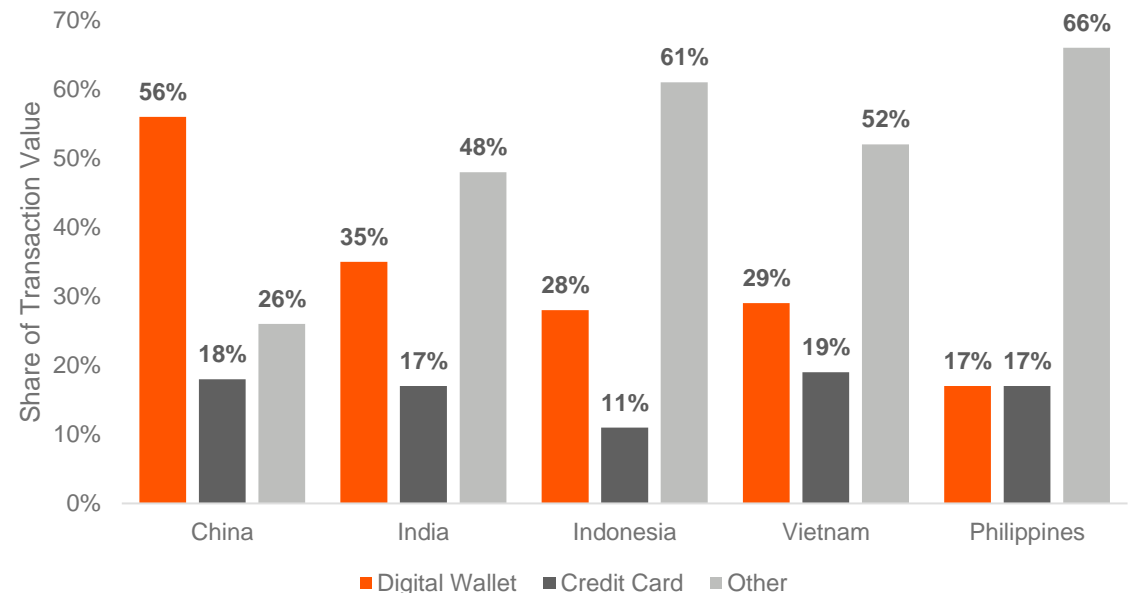
E-Wallet vs. Major Credit Card Merchant Take Rates



Note: Average interchange rates for Visa Card “card present” transactions is 2.10% + \$0.10, while card not present rates are 2.40% + \$0.10. This is aside from the additional assessment fee.¹

Emerging Markets Turn to E-Wallets Over Credit Cards

2022 Point-of-Sale (POS) Payment Methods Estimated Share of Transaction Value

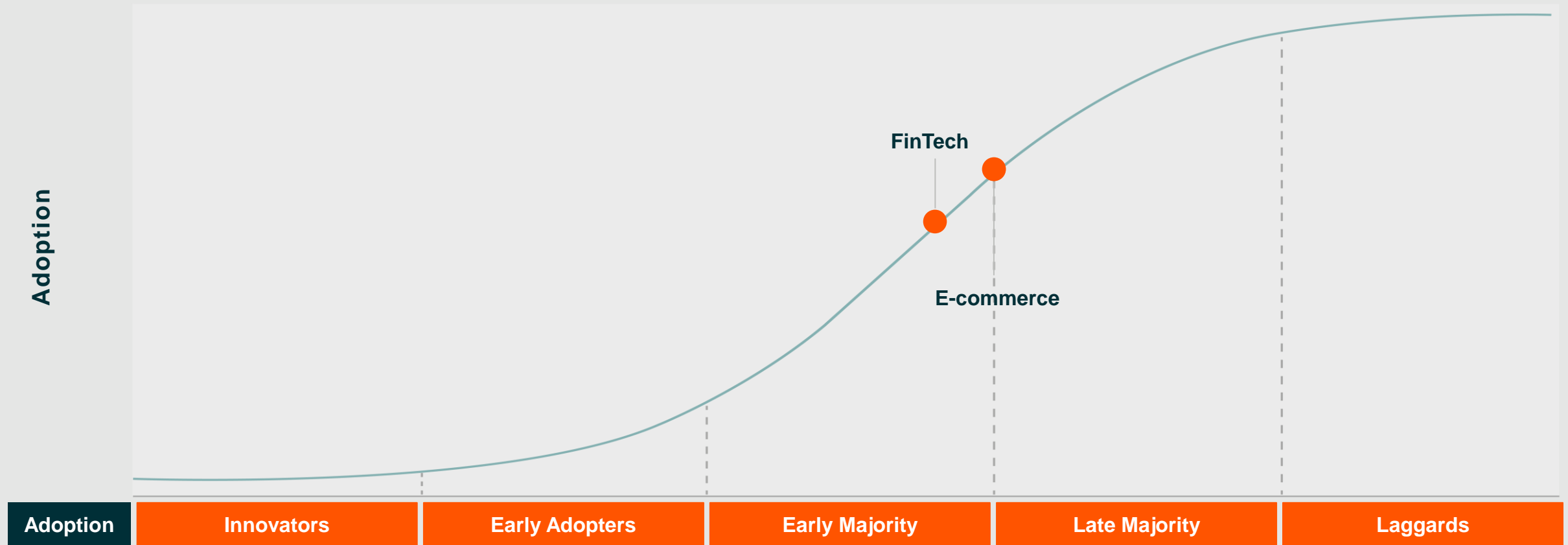


Note: Other includes Debit Card, Cash, POS Financing, and Prepaid Cards.

Sources: Text: 1. FastSpring, 2018; Charts: Left: Oceanpayment, 2021; Shopify, 2021; PayPal, 2023; Right: WorldPay from FIS, 2023

Clicks & Commerce: S-Shaped Curve of Adoption

The future of commerce is omnichannel, with digital financial solutions playing a key role in disrupting legacy players.



Note: For illustrative purposes only.

Paradigm-Shifting Technologies

Pixels, Unleashed

Interactive Entertainment in the Age of Bits

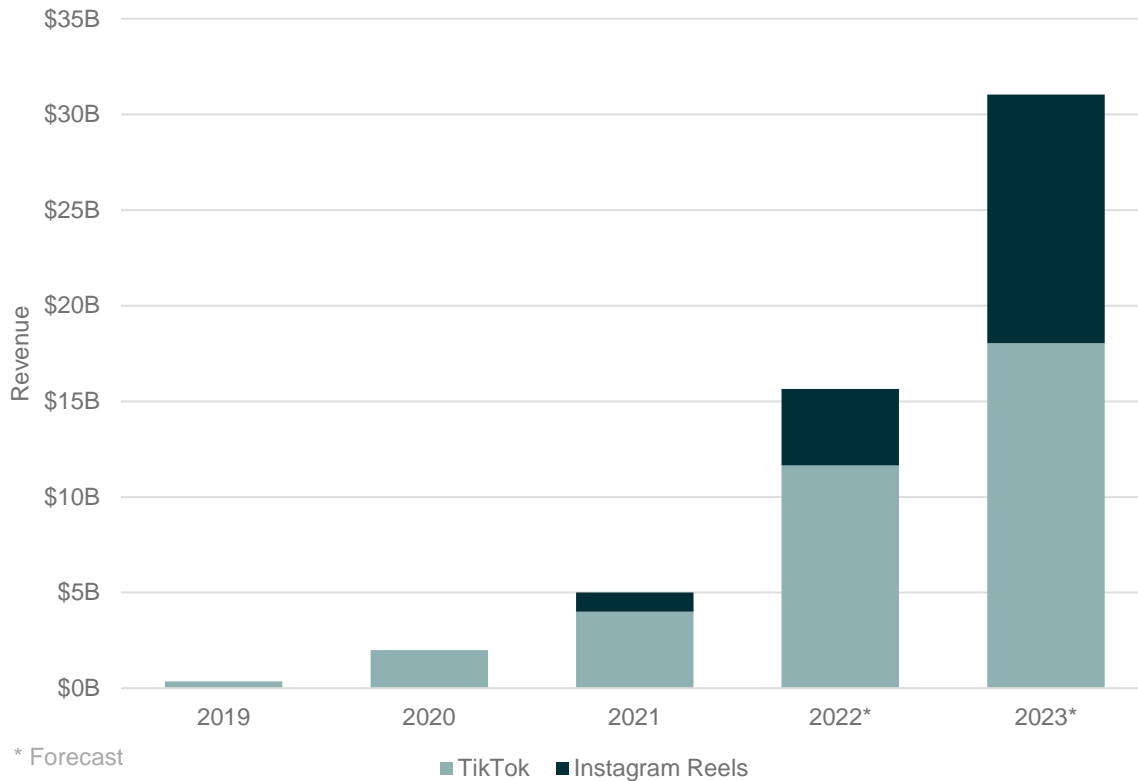
Digital experiences like streaming and social media continue to advance at healthy rates, discovering new frontiers for development based on format and feature innovation. For example, short video provides large platforms with alternative opportunities for growth. Similarly, gaming is on the rise again in key markets like the United States after its post-COVID slump. Meanwhile, Apple's Vision Pro Headset marks a major step in the build-out of immersive experiences, and early experiments show credible traction.



Short-Form Videos Are Boosting Digital Ad Revenues and Helping Platforms Return to Growth

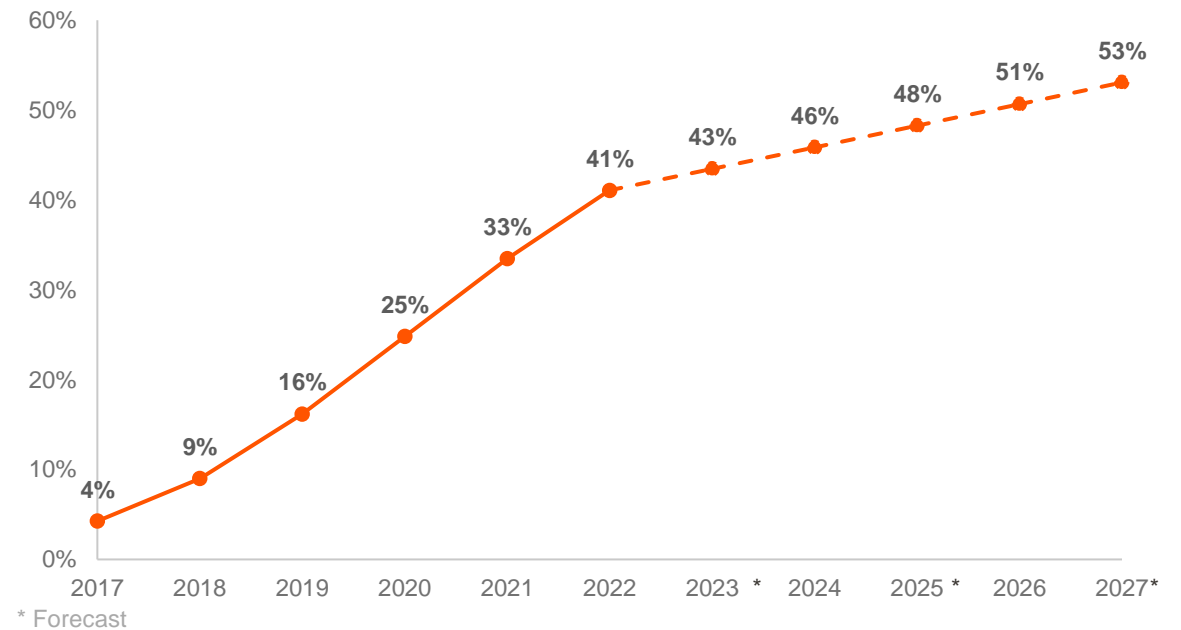
Online videos are in a format-driven transition, with short-form content driving growth for leading platforms. Meta’s Reels is eroding TikTok’s dominance and setting a course for the rest of the content industry to follow.

TikTok and Reels Short-Form Video Revenue



Short-Form Video Advertising Continues to Gain Traction

Short-Form Video Ad Share of Total Video Ad Spending in the United States



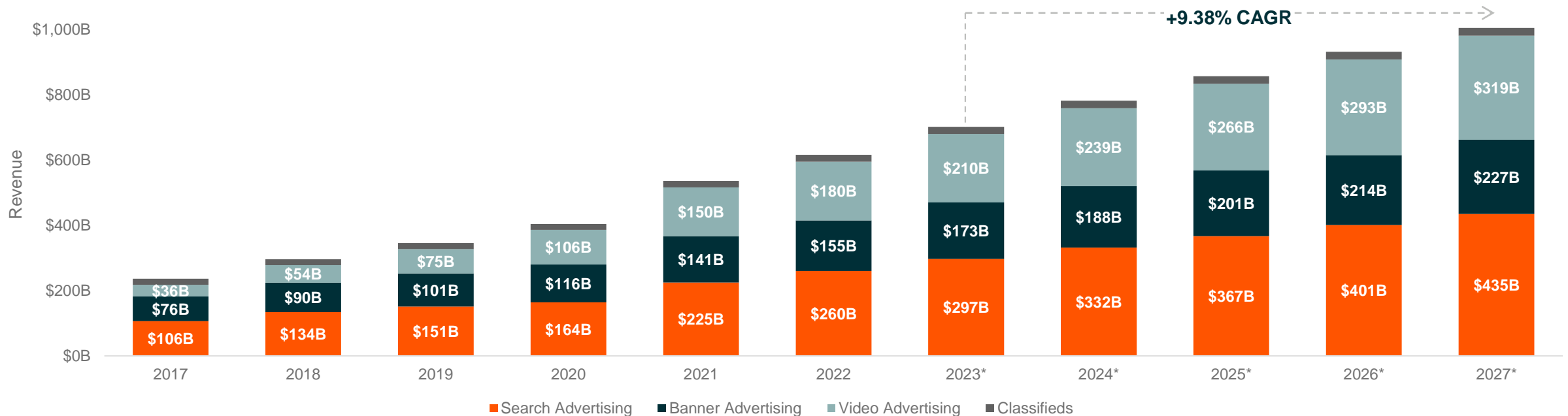
Sources: Chart: Left: eMarketer, 2022; Right: Statista Market Insights, 2023

Global Digital Advertising Market Is Far From Saturation

A handful of dominant platforms control a significant portion of the digital advertising landscape, capitalizing on emerging features and cutting-edge technologies to drive incremental profits.

Video Advertising Revenue Is Expected to Grow From 15% to 32% of Total Digital Advertising Revenue in 2027

Global Digital Advertising Revenue



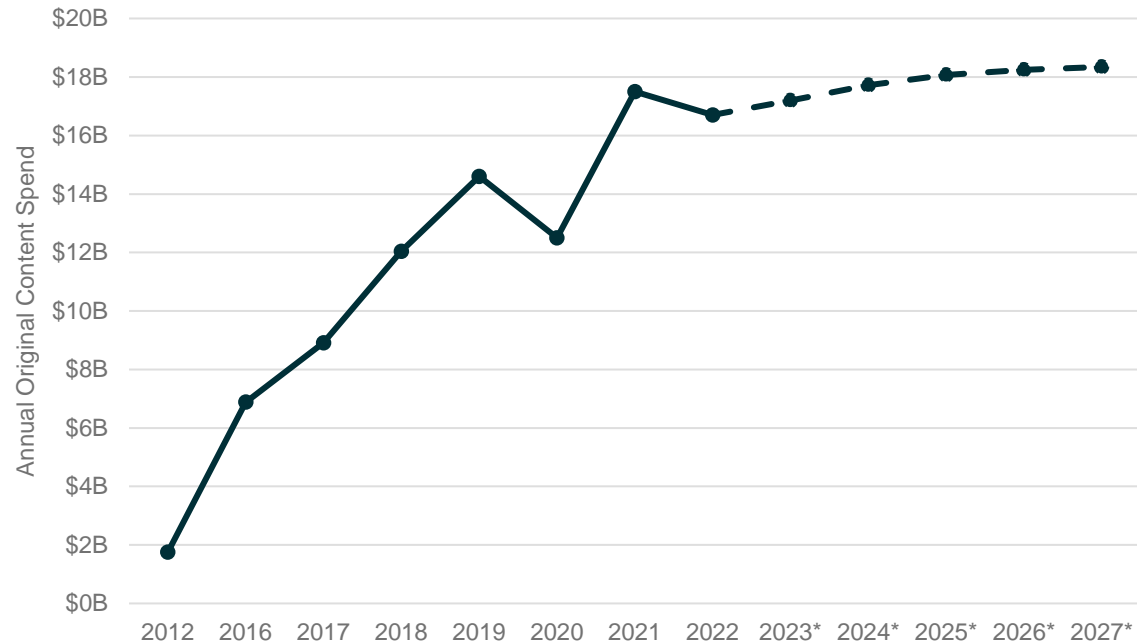
Sources: Interactive Advertising Bureau, PWC, 2023

Generative AI Could Simplify Content Creation, Boosting Impressions and Revenues

Generative artificial intelligence (AI) could play a pivotal role in entertainment and content production processes, to create an era of human-generated, AI-augmented content.

AI Could Cut Content Costs, Improving Streaming Margins

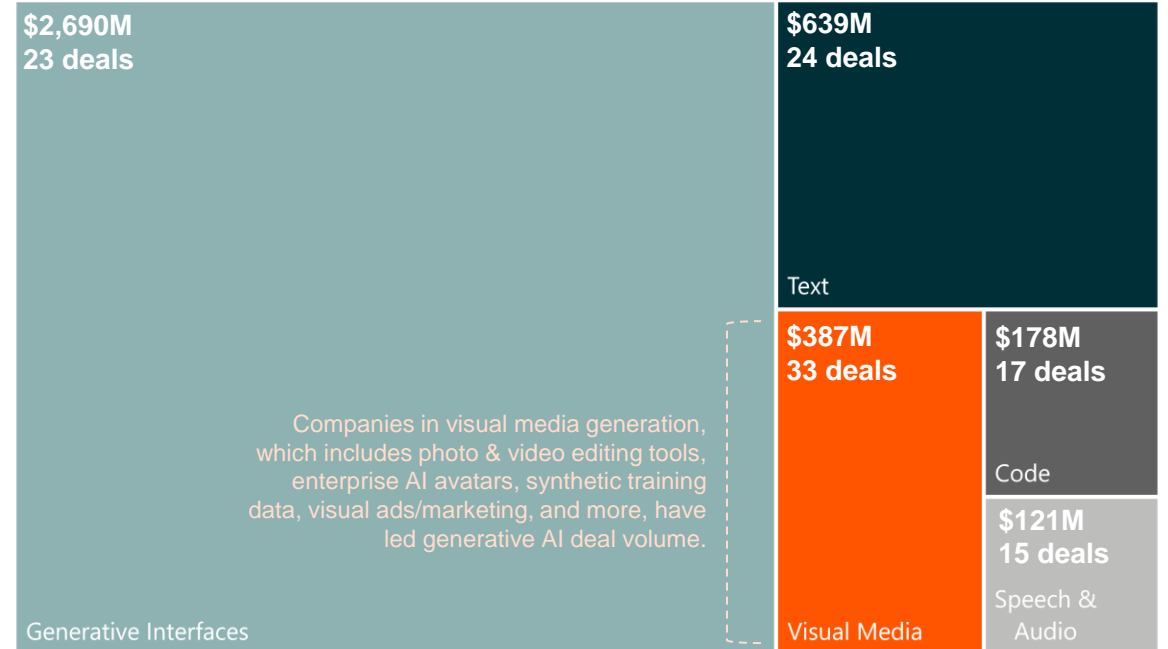
Netflix Annual Content Spending



* Forecast

Companies Spent \$387M on Gen AI Funding in Visual Media

Distribution of Generative AI Funding, Q3 2022 - Q2 2023



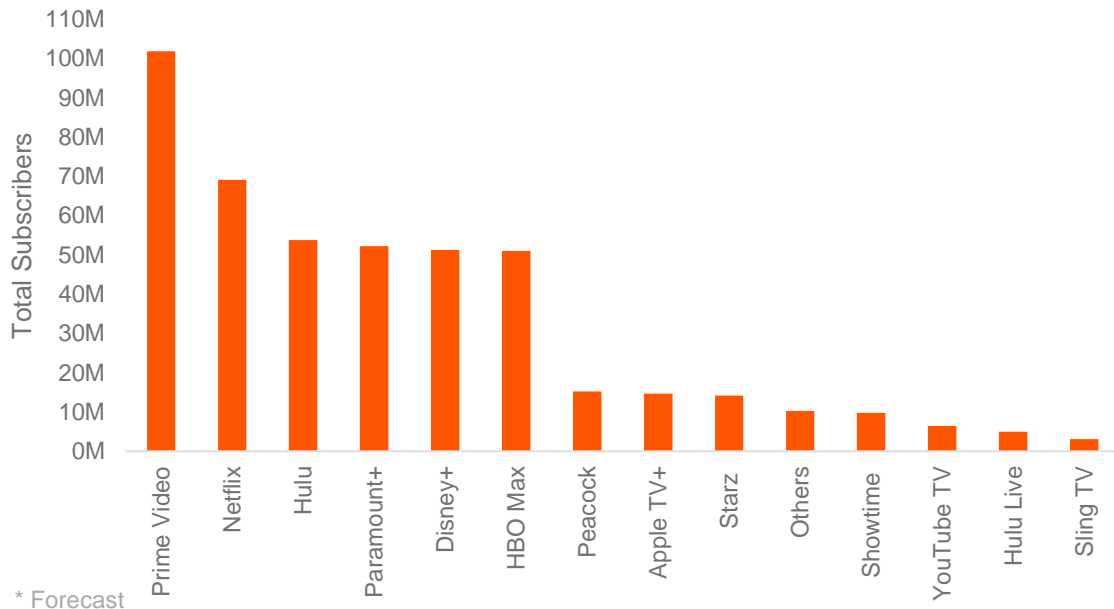
Sources: Charts: Left: Ampere Analysis, 2023; Netflix Investor Relations 2012 – 2022; Right: CB Insights, 2023

Favorable Pricing Power Can Help Streamers Thrive Despite Competition and Fragmentation

Consumers are expected to maintain a preference for diverse streaming options, intensifying competition among streaming providers. However, streamers have a track record of discovering new pricing strengths.

SVOD Market Is Expected to Remain Widely Fragmented

U.S. Subscription Video On Demand (SVOD) Subscribers by 2027

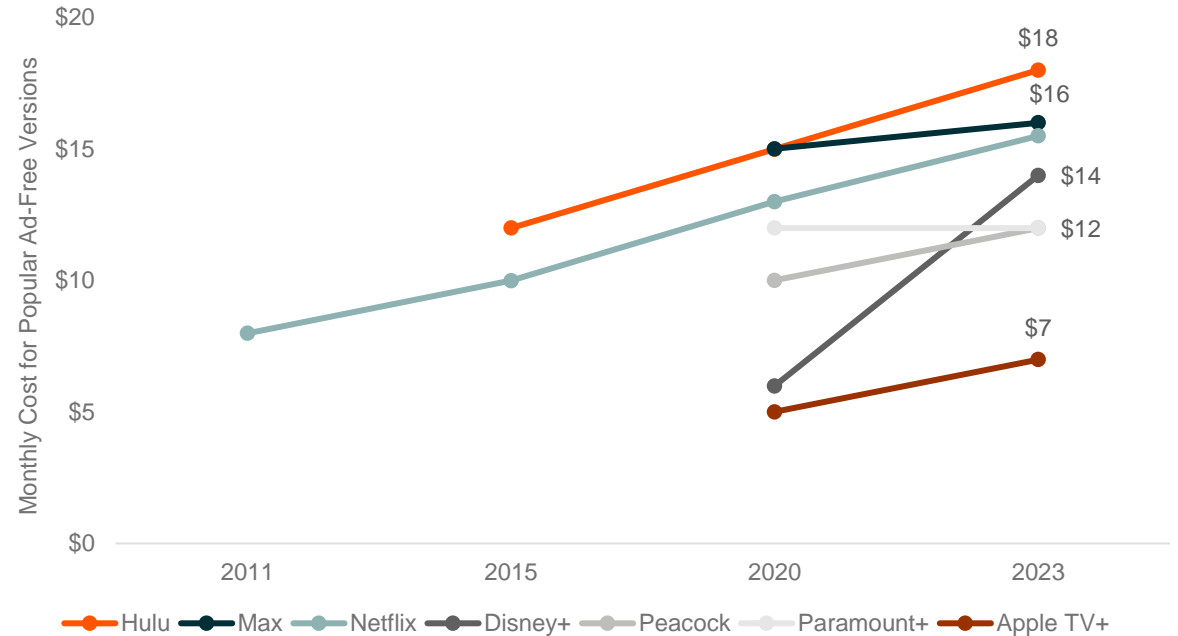


Note: Amazon Prime Video includes all Amazon Prime subscribers.

Sources: Charts: Left: Digital TV Research, 2022; Ampere Analysis, 2023; Right: The Wall Street Journal, 2023

Despite Competition, Streamers Have Strong Pricing Power

Prices Over Time for Leading Streamers

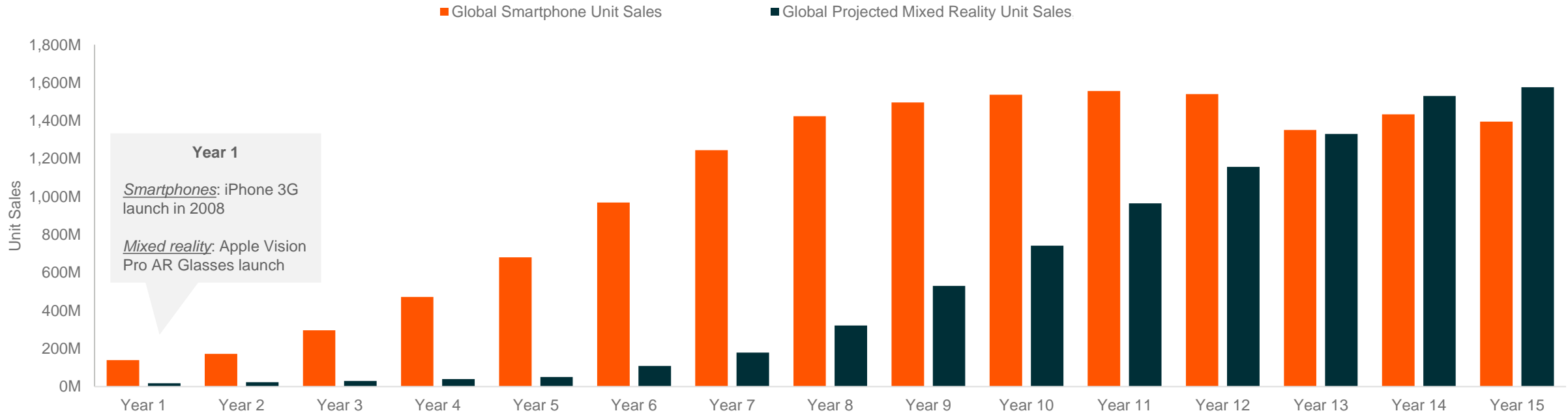


Immersive Technology Set to Revolutionize Consumer Devices

Mixed reality headsets are the next major innovation in consumer technology, allowing users to participate in immersive experiences. Headset technology must mature, but its adoption may rival smartphones in 15 years.

Apple's Vision Pro Launch in 2024 Will Likely Mark a Critical Moment for the Industry, Igniting a Cost Decline

Comparing Smartphone Unit Sales with Projected Mixed Reality Unit Sales



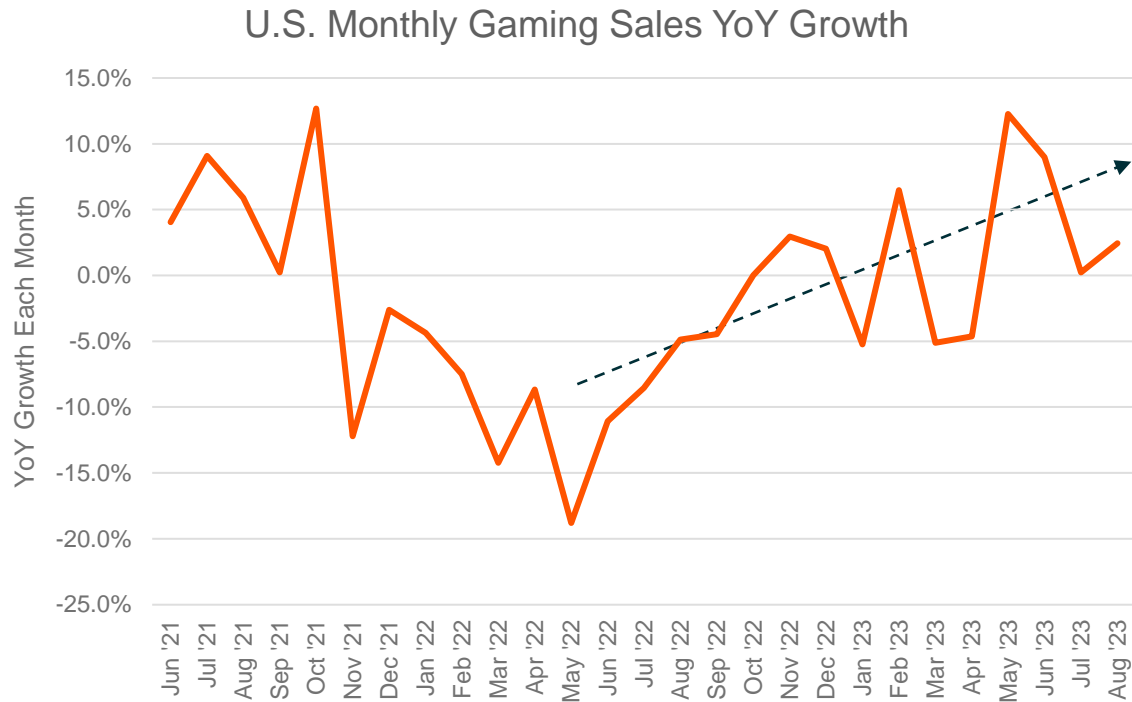
Note: For illustrative purposes only.

Sources: AR Insider, 2021; International Data Corporation (IDC), 2022

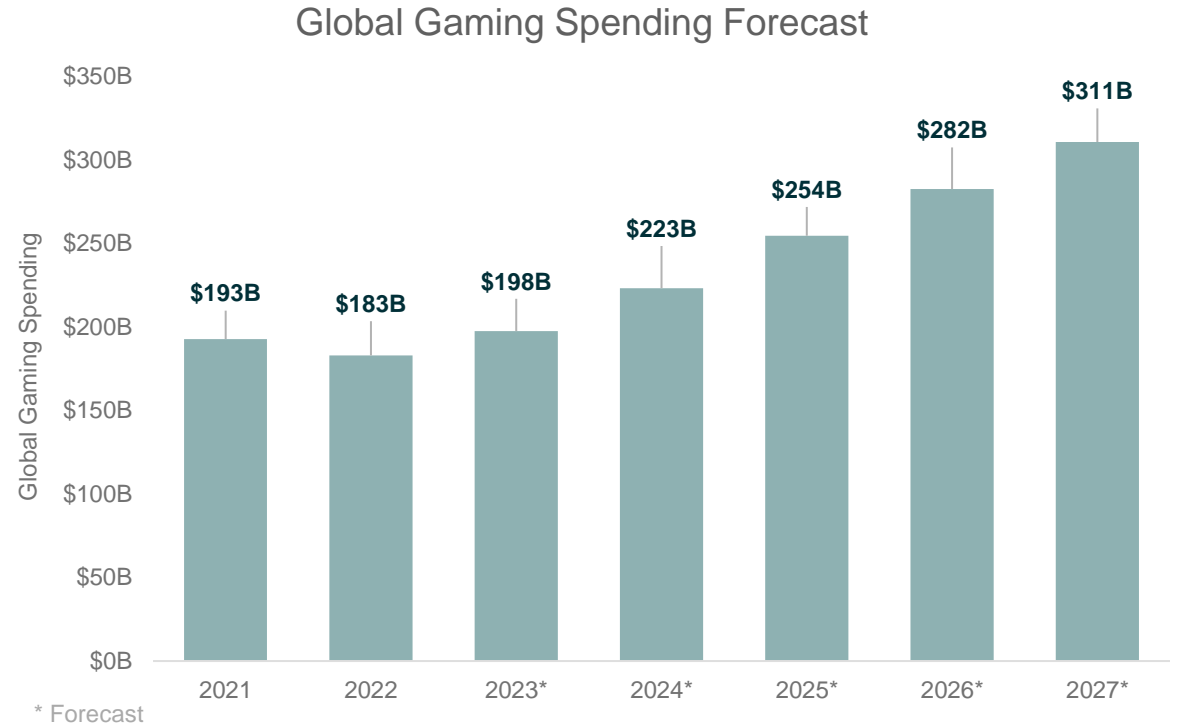
Video Games Are Returning to Growth After Post-COVID Withdrawal

After a brief pause in 2022, the video game industry already shows signs of recovery. U.S. gaming hardware sales, a leading indicator for software and services, grew 23% YoY in the first half of 2023.¹

Total U.S. Gaming Sales Topped \$26.5 Billion in H1 2023



Global Game Spending Is Expected to Grow 12% in 2024

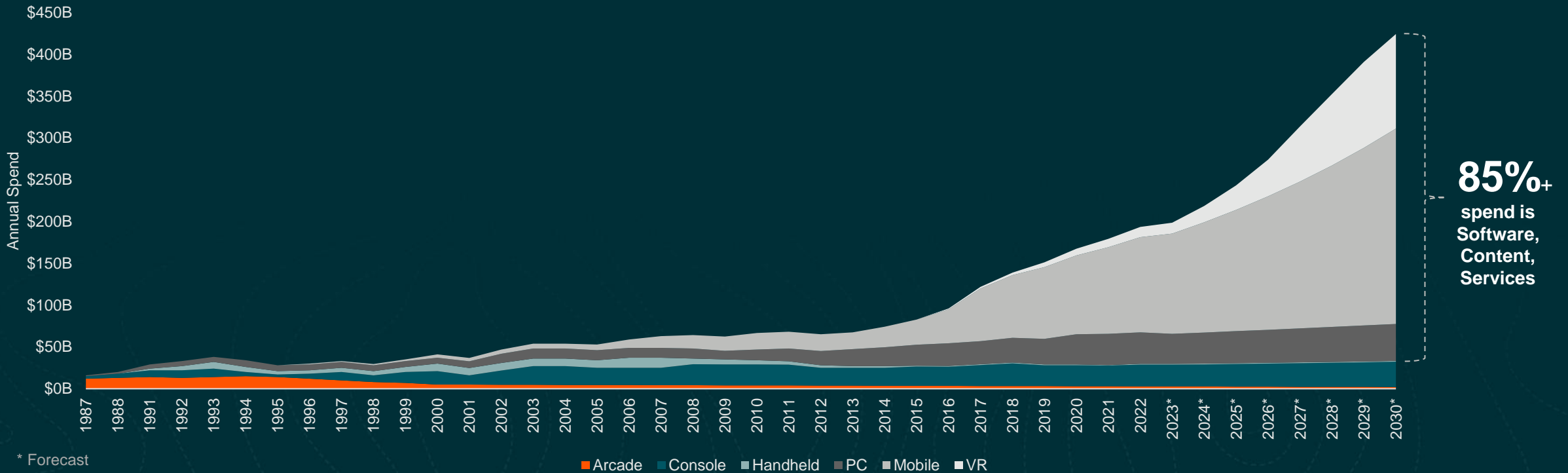


Sources: 1 Circana (2023, August 03), The Gaming Market in the U.S. Grew by 9% in June 2023; Charts: Left: Circana, 2023; Right: New Zoo, 2022

Software and Content Set to Power Video Games Value Creation

Software and mobile games are expected to supplant hardware and consoles as the main growth drivers for the gaming industry in the coming years. Immersive gaming, cloud gaming, and eSports are industry tailwinds.

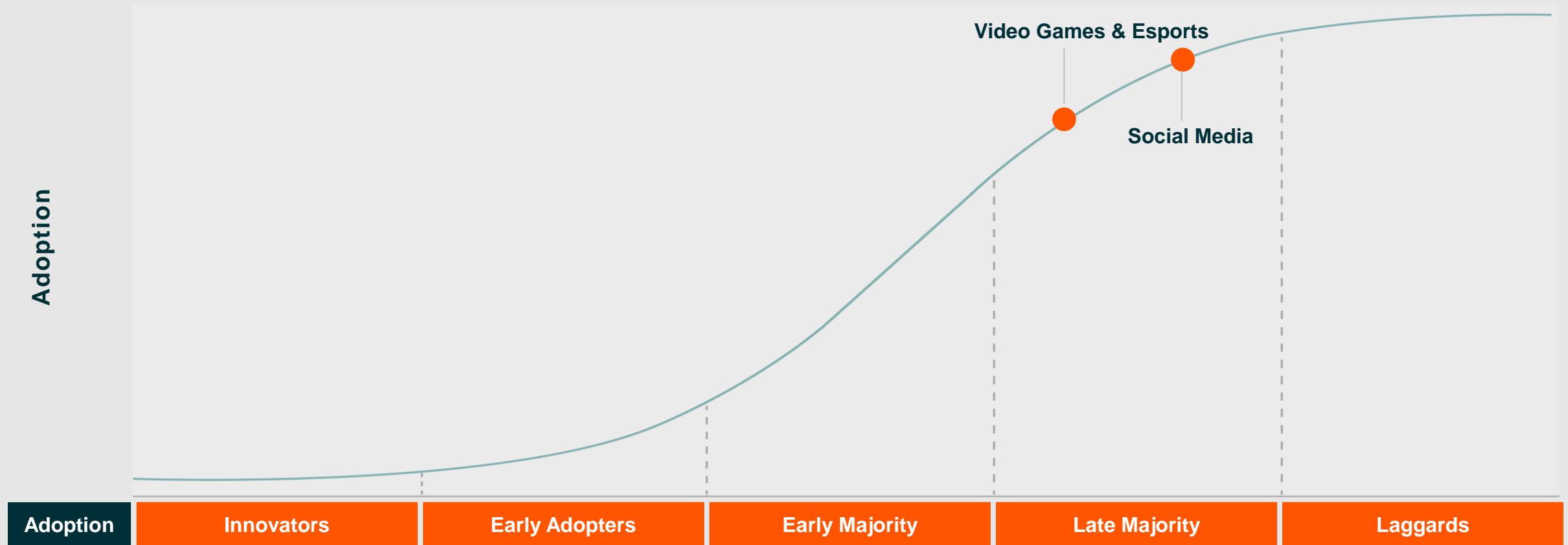
Global Gaming Spending



Sources: World Economic Forum, 2020; New Zoo, 2022

Pixels, Unleashed: S-Shaped Curve of Adoption

Shift of consumer attention and dollars will continue to migrate to digital channels through this decade.



Note: For illustrative purposes only.

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Appendix: Artificial Intelligence

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