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INDUSTRY AND EMERGING TECH RESEARCH

2023 Industry and Technology Outlook

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2023 outlooks

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AGTECH: SMART FIELD EQUIPMENT

Outlook: Robotics & smart field equipment will receive record funding.

> **Rationale:** The pandemic highlighted the importance of food supply and food security. Climate change, rising global populations, and geopolitical issues have only made these issues more urgent, necessitating innovative technologies to scale production. Farm equipment employing automation, artificial intelligence & machine learning (AI & ML), computer vision, and other advanced technologies has improved significantly and is now beginning to see commercialization. The combination of a growing market opportunity and approaching market readiness will likely contribute to record funding of the category in 2023.
>
> **Risks:** Developing new smart farm equipment is capital- and time-intensive. Furthermore, the challenge of establishing the infrastructure to build, sell, and maintain the equipment is equally complex and costly. Farmers may instead purchase new equipment from trusted incumbents such as Grainger, Deere, and Kubota, which are developing or acquiring advanced technologies.
>
> Market volatility and headwinds in the venture space are likely to have a more profound effect on capital-intensive hardware businesses. Robotics & smart field equipment providers may struggle to secure funding in the current environment, with increased scrutiny over burn rates and paths to profitability.

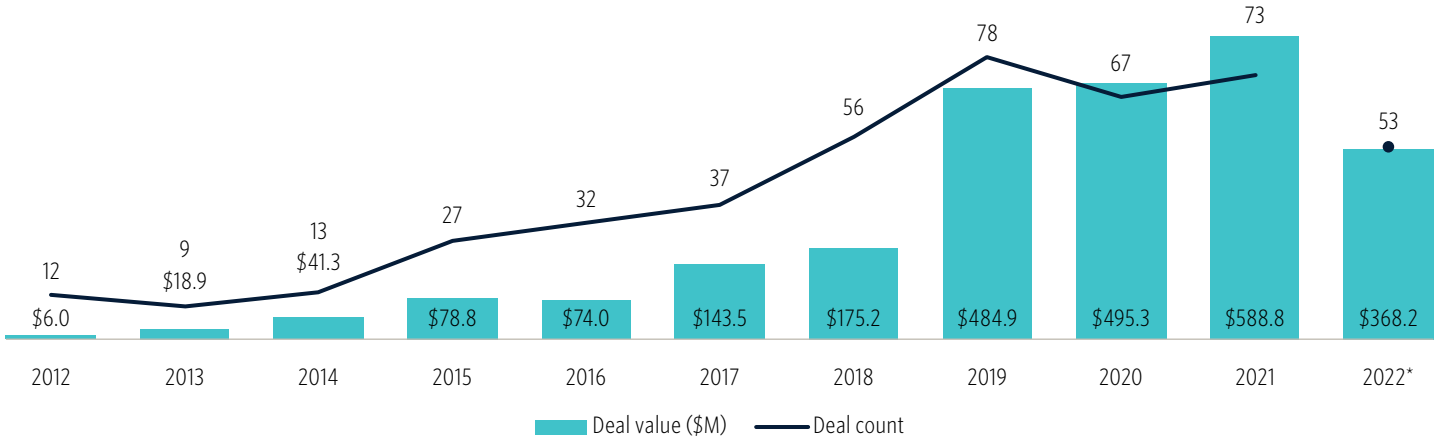
Robotics & smart field equipment includes advanced farm machinery that automate and optimize in-field operations. These machines and farm implements improve common farm activities such as scouting, seeding, spraying, and weeding. Technologies including AI, computer vision, and digital twin enable unprecedented precision, automation, and decision support.

The fragility of the food system was highlighted during the pandemic, when blockages to transport, logistics, and farm labor led to the loss of millions of tons of food worldwide. Many of the same challenges persist two years later, and the war in Ukraine, climate change, and industrial agriculture practices are contributing to depleted yields. Climate change, extreme weather events, and aridification are only expected to worsen in the long term, which will strengthen the value proposition of robotics & smart field equipment

Advanced field machinery offers farmers a variety of benefits. Monarch Tractor's MK-V model is electric and has automation capabilities. An electric motor offers energy cost savings and emission reductions, while automation enables farmers to plant and harvest greater acreage with reduced labor requirements. Verdant Robotics' spraying implements use computer vision and articulated nozzles to target individual weeds instead of coating the entire field, thus reducing input costs and health concerns for farm workers and consumers. Clearpath Robotics is developing small-scale farm machinery that reduces soil compaction, thereby improving plant

growth, seed emergence, and crop yields. Many of these startups are in the research & development (R&D) and field trial stages and are nearing commercialization. Monarch Tractor recently shipped its first batch of MK-V tractors to beer, wine, and spirits producer Constellation Brands. The sector will likely become increasingly attractive to investors as companies prove out their technologies through successful field trials.

Robotics & smart field equipment VC deal activity



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*As of September 30, 2022

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ARTIFICIAL INTELLIGENCE

Outlook: AI startups will stand out by applying imitation learning to foundation models for task completion.

Rationale: Recent research into reinforcement learning and imitation learning for agent-based AI can produce commercial business models, particularly if they are embedded within foundation models such as OpenAI's upcoming GPT-4.

Risks: Imitation learning remains unproven in a commercial context and may suffer from a lack of quality data on user task completion, including tutorials and videos of user screens while completing tasks.

Large language models have gained traction with prompts as an interface, yet lack the capacity to predictively carry out manual tasks or learn from prior interactions. As a result, startups are building user interface wrappers around language model application programming interfaces (APIs) to translate queries into business functions, such as copywriting and coding. In a sign of improved task completion abilities, Meta's AI agent, CICERO, learned how to play the board game Diplomacy based on imitation of other players' playing styles. The system can learn from players' words via natural language understanding and actions via imitation learning, thus identifying the communication and action steps that lead to optimal outcomes. The result is a self-sufficient program that can perform a complex task at human level in communication with human players. This research shows that large language models can be used to interact with agentic models to complete tasks.

OpenAI's and Nvidia's research in this area indicates that imitation learning will become part of future foundation models. In June 2022, OpenAI published a paper on imitation learning for Minecraft that learned from keystrokes and mouse movements on 70,000 hours of gameplay.[1] Recently, at leading academic AI conference NeurIPS, a paper coauthored by an Nvidia research scientist won a conference prize for outstanding datasets and benchmarks with a paper also on Minecraft. The authors' imitation learning model learns from gameplay video along with online forum comments and game-related wiki pages. Players can interact with the bot via natural language to execute tasks, thereby enabling control of intelligent bots without an explicit reward function. The inclusion of natural language augurs a future wherein large language models can be connected to actions learned from a vast corpus of internet actions and tutorials.

Startups that apply the latest innovations in academic research can generate significant value at an early stage. In 2022, leading early-stage deals for Stability AI and Jasper AI depended on innovations in text-to-image diffusion models and natural language generation models, respectively. OpenAI first popularized diffusion models, which stood out for the quality of images they produced. However, they

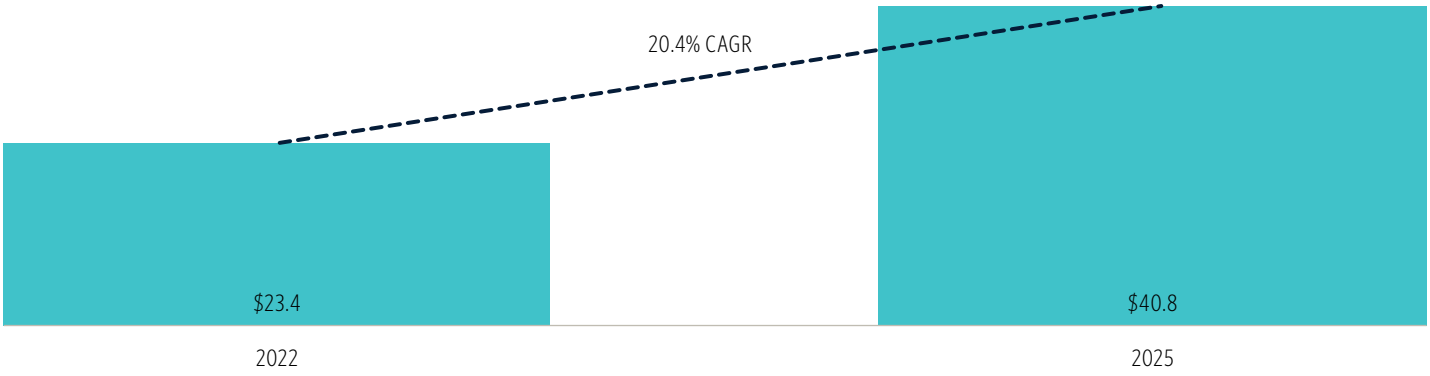
1: "Learning to Play Minecraft with Video PreTraining (VPT)," OpenAI, June 2022.

became susceptible to open-source disruption via startups including Stability AI and Midjourney. GPT-3's natural language generation model became generally available in Q4 2021 and produced large businesses less than one year later. Similar innovations in 2022 will create large businesses in 2023, and we believe agentic models incorporating imitation learning are likely to move the field forward.

The latest foundation models have separated startups from their competition, and new innovations will likely yield similar commercial results. In 2021, transformer models enabled outstanding growth for language generation startups. In 2022, diffusion models and state-of-the-art large language models yielded impressive results for generative AI companies. We believe OpenAI plans to release GPT-4, the next of its large language models, in 2023. This model may be able to learn from a vast corpus of internet data including videos, voices, and code, along with improving understanding of the natural language defining how humans describe this data. Given OpenAI's research in imitation learning and usage of reinforcement learning in its ChatGPT product, we believe GPT-4 will also include some forms of reinforcement or imitation learning to connect sequences of prompts and enable task completion. The model may offer startups commercial abilities not present in prior models.

Imitation learning techniques can disrupt the $23.3 billion intelligent process automation (IPA) market. The IPA market has evolved from the conventional robotic process automation market to incorporate process mining and task mining. The latter two product types track user processes to automate common workflows. Incorporation of machine learning into these products remains limited, with high latency for updating predictive models. General-purpose AI models may be able to apply inferences from foundation models incorporating imitation learning to replicate human actions in near-real-time across a wide domain. Incumbents may find themselves behind in the application of state-of-the-art AI techniques to process automation.

Intelligent process automation market size estimate ($B)*



Source: IDC | Geography: Global
*As of September 22, 2022

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CLIMATE TECH

Outlook: US VC investment in climate tech will reach a new peak.

> **Rationale:** Driven by the US' Inflation Reduction Act (IRA), increasing acceptance of the need to manage climate change, and pledges to reduce emissions, interest in climate tech is climbing. The most significant US climate bill of the twenty-first century, the IRA provides federal support for a range of climate technology areas.
>
> **Risks:** Though the bill is wide-reaching, some climate technology areas are not included and remain largely unsupported from a federal perspective in the US.

General conditions for the climate tech space are strong, with high interest at individual, corporate, regional, and country levels. This interest manifests through pledges to reduce carbon emissions, and these pledges increase the market for technology solutions. In addition, technological maturation has allowed certain applications of climate tech to become economically viable—even ignoring their environmental benefits. Advances in battery technology, for example, have made electric vehicles a truly viable alternative to conventional vehicles; they have also enabled relatively low-cost grid- and residential-scale batteries that can generate revenue or reduce residential electricity costs. Similarly, solar panel prices have dropped substantially in the last 10 years, and home installations are now a viable way to reduce electricity bills—more salient this year than ever—even for users uninterested in their carbon footprint.

VC investment in climate tech was particularly strong in 2021, and so far, 2022 has seen similar levels of investment. On top of this, the IRA was signed on August 16, 2022, and it represents the largest-ever US climate bill.[2] The IRA provides approximately $370 billion in broad support for climate technologies, though total federal support is expected to exceed this initial figure. Because the IRA was signed in Q3 2022, we expect significant changes to VC investment to ramp up in 2023 and beyond.

In the IRA, a few spaces are particularly well-represented:

- **Carbon removal** tax credits are bolstered significantly by the IRA and represent uncapped tax credits that can be claimed by those that capture and store carbon dioxide. The value per ton has increased significantly—from $50 to $85 per ton for point-source carbon capture and storage (CCS) and from $50 to $180 per ton for direct air capture—and thresholds for eligibility have been reduced.[3] Further, the credit is now available through direct pay, as it is considered overpayment of taxes and can therefore be used by those with low tax liabilities. The IRA differentiates direct air capture technologies, which were previously lumped in with point source carbon capture. This differentiation benefits direct air capture startups, which tend to be small, early-stage companies.

2: The bill includes some non-climate-related items, but the majority of the content covered focuses on climate change mitigation.
3: "The US Inflation Reduction Act of 2022," Global CCS Institute, August 27, 2022.

- **Renewable energy** support is implemented at various stages and aims not only to improve overall penetration of renewable power generation, but to onshore production of hardware and bolster domestic manufacturing. Support includes tax credits for production of renewable energy hardware and construction of manufacturing facilities, in addition to tax credits for production of clean energy and energy storage.
- **Residential energy efficiency** is a core way to reduce energy usage, and the IRA provides support for high-efficiency HVAC installation, plus residential heat pumps and solar panels.

The additional support that the IRA provides can be leveraged by startups in the climate tech space to boost their viability or scale more quickly. Projections of total US renewable power generation capabilities show substantial increases, up to 2.5x the current capacity by 2030, driven partly by the IRA.[4] While this will ultimately come from a combination of sources, we expect VC-backed companies to play a significant role in this projected increase.

US-based VC climate tech startups to watch*

Company	Segment	Category	Post-money valuation ($M)	Total VC raised ($M)	Reason to watch
Palmetto	Intermittent renewable energy sources	Solar photovoltaic	$1,000.0	$429.5	Provides a residential solar services platform, allowing users to plan, install, manage, and maintain solar installations
Caelux	Intermittent renewable energy sources	Solar photovoltaic	$60.0	$22.7	Develops perovskite-based solar modules, potentially offering higher efficiencies than conventional modules
Travertine	Carbon tech	Direct air capture	$12.0	$3.0	Developer of direct air carbon capture technology that also produces chemical co-products
Verdox	Carbon tech	Point source CCS, direct air capture	$198.9	$170.1	Developer of low-energy carbon capture chemistry, reducing operational costs of carbon capture
Sealed	Built environment	Building energy efficiency	$235.5	$57.7	Provides energy efficiency improvements to homes and buildings, including insulation, energy-efficient HVAC, and smart home technology

Source: PitchBook | Geography: US
*As of December 15, 2022

4: "World Energy Outlook 2022," International Energy Agency, October 2022.

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CRYPTO

Outlook: Crypto VC funding will bottom out during the first half of 2023 and move higher later in the year.

> **Rationale:** Market fear, uncertainty, and doubt have percolated across the crypto space in 2022 as many prominent market participants suspended operations and/or filed for bankruptcy, which led to decreased crypto investment. However, investors will likely become more comfortable investing in crypto in late 2023 as we lap 2022's failures and see more regulations, better risk management, and real-world use cases. Additionally, our data shows that there is meaningful VC dry powder that is earmarked for new crypto startups.
>
> **Risks:** If macroeconomic conditions further deteriorate, investment activity could be temporarily halted, particularly in highly risky areas such as crypto.

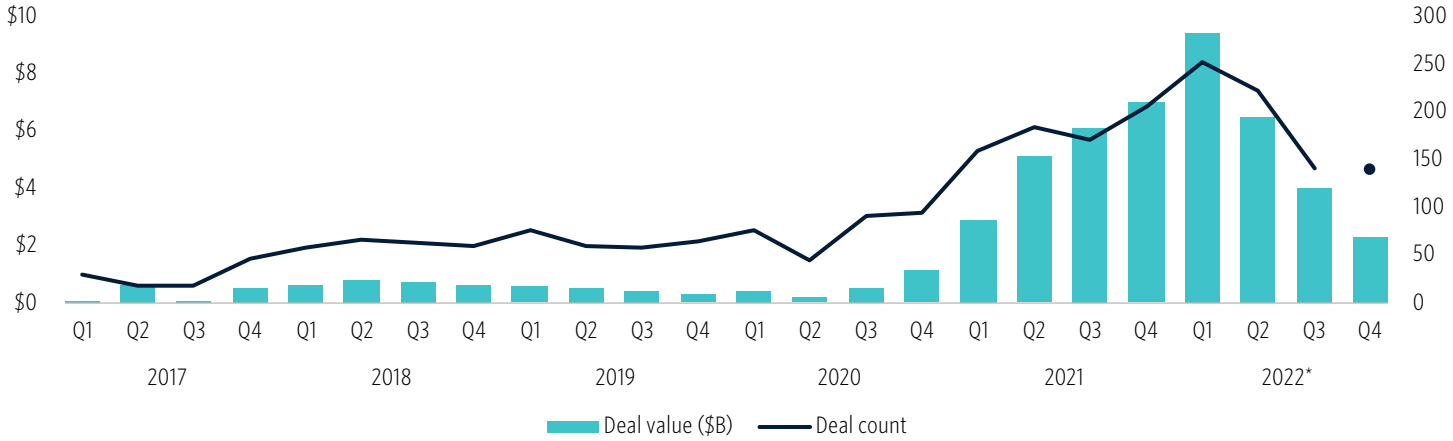
2022 was a challenging year for crypto markets as the total crypto market cap collapsed, declining from about $3.0 trillion to sub-$1.0 trillion and remaining low. While some systemic risks such as overvaluation in private and public markets, rising interest rates, and macroeconomic headwinds affected crypto markets in 2022, idiosyncratic risks such as speculation, leverage, severe lack of risk management, and regulatory uncertainty adversely impacted the space. The sudden failures of many VC-backed crypto startups such as Terraform Labs, Celsius, BlockFi, and FTX also led investors to reduce capital deployment into crypto. Although global venture investments into crypto companies in aggregate remained elevated in 2022 and are on track to surpass 2021's record $21.2 billion, the bulk of investment capital was completed during the first four months of the year, before the collapse of the Terraform Labs' Terra Luna ecosystem, which led to widespread fear in the crypto markets. Our data shows that the final eight months of 2022 saw a steep downward slope in VC investments—from roughly $4 billion per month to less than $1 billion—a trend that we expect to continue into 2023. We also expect the token market cap to continue to correlate tightly with VC crypto investments.

A few factors in 2023 could drive a turnaround and increase investor confidence in crypto later in the year. The lack of regulatory clarity has been a constant source of friction for crypto markets since crypto's inception, but that is starting to change. We expect the EU's recent crypto legislation, the Market in Crypto-assets Regulation (MiCA), to be ratified sometime in early 2023. Although the law won't go into effect until 2024, the bill's final passage will give industry stakeholders the most comprehensive, clear set of rules to date. In the US, congressional hearings will likely increase in 2023 and will heavily involve industry participants, regulators, and individuals involved in failed crypto companies. These hearings will help legislators fast-track their understanding of crypto risks and opportunities, which will likely lead to the passage of at least a couple of bills regarding crypto assets during 2023.

We also expect that users will demand better risk management and transparency of crypto. There will be less tolerance for centralized, opaque operating models, with some activities such as trading, leverage, or yield generation shifting to more transparent decentralized finance (DeFi) protocols. Investors will likely seek to invest in crypto companies with real-world use cases, as these businesses should

be more sustainable than those that seek only to serve crypto users and other crypto companies. Companies such as Jia, which uses crypto infrastructure to deliver banking services in developing countries, will become more attractive for VC investments. Lastly, plenty of dry powder is available to invest in crypto companies, with dedicated crypto VC firms such as Haun Ventures, Paradigm, and CoinFund having yet to deploy much of the capital from recently raised funds.

Crypto VC deal activity



Source: PitchBook | Geography: Global
*As of December 5, 2022

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E-COMMERCE

Outlook: Intense competition, international growth, and adoption in nontraditional industries will push livestream commerce to record VC funding.

> **Rationale:** The rise of influencer personalities, global digitization, and mobile commerce (m-commerce) are poised to coalesce in both domestic and emerging markets to disrupt established digital business models.
>
> **Risks:** E-commerce and social media titans are developing native features and functionality that create significant headwinds for livestream commerce startups.

Livestream commerce enables the selling of goods via live social media feeds wherein consumers watch online personalities or influencers discuss and demonstrate the value of various products. Users can engage with hosts and participants via real-time reactions or questions, which have the potential to significantly boost conversion rates. This shopping method is already dominant in certain regions, such as China, and in industries, such as fashion and cosmetics. Famously, a staggering $8 billion was spent via livestream commerce in the first 30 minutes of Singles' Day in 2020,[5] and estimates suggest livestream commerce could exceed $400 billion annually in China.[6] By comparison, recent figures indicate Amazon's eighth-annual Prime Day yielded approximately $12 billion in sales.[7] Prominent brands, including Burberry, Louis Vuitton, and Nordstrom, are also experimenting with this medium.

A critical growth driver for livestream commerce is emerging market adoption. In India, Flipkart, recently acquired by Walmart, is currently testing livestream functionality, and Amazon has already deployed over $6 billion to penetrate the e-commerce market in India, which is project to exceed $130 billion in the coming years.[8] Regional livestream apps, such as India's shopr.tv, are also cropping up, positioning themselves to attract additional capital. Latin America is similarly positioned for both e-commerce and livestream growth. A strong presence from e-commerce incumbents—including Argentina's Mercado Libre, which has a market capitalization approaching $50 billion, and Amazon.br—is demonstrating an eagerness to deploy scalable capital alongside a growing population of digital-native shoppers.[9]

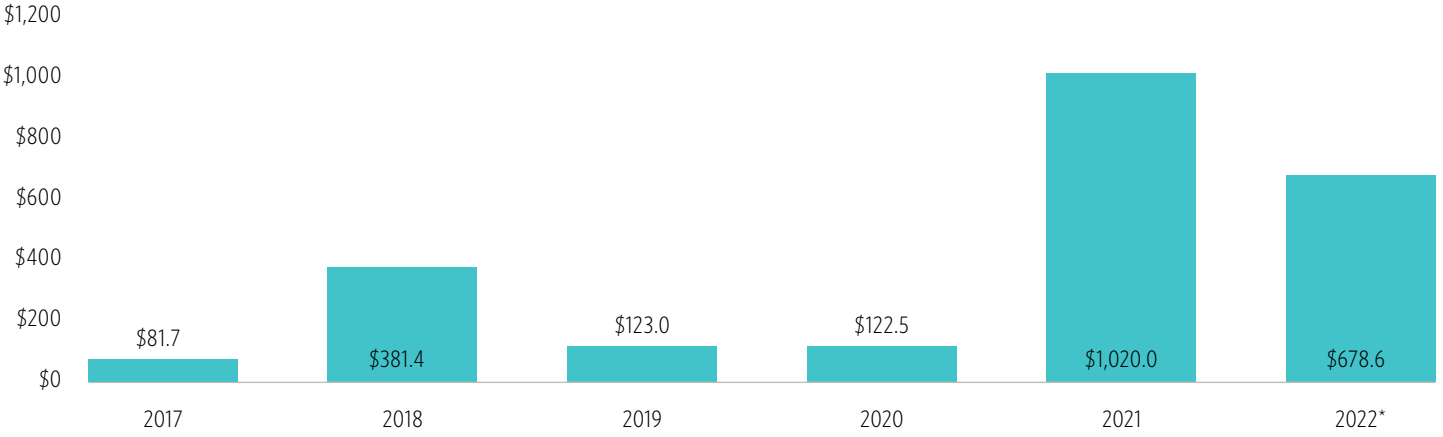
Additionally, adoption in nontraditional, adjacent markets is poised to increase the value of livestream commerce startups. For example, Amazon-owned Twitch, with its 10 million daily active users, announced another iteration of the "Pog Picks" event, which incentivizes users to complete gaming challenges in order to access products.[10] The gaming industry, with over 3 billion participants and over $330 billion in revenue,[11] presents significant upside, alongside deepening adoption in traditional consumer goods.

5: "It's Showtime! How Live Commerce Is Transforming the Shopping Experience," McKinsey Digital, Arun Arora, et al., July 21, 2021.
6: Ibid.
7: "Amazon's Prime Day 2022 Sales Top $12 Billion," Digital Commerce 360, Jessica Young, July 14, 2022.
8: "Amazon Launches QVC-Style Livestream Shopping in India," *TechCrunch*, Manish Singh and Jagmeet Singh, September 29, 2022.
9: "Global E-Commerce Trends Report," J.P. Morgan, 2022.
10: "Twitch Bets on Livestream Shopping with Expanded Holiday Programming," Marketing Dive, Jessica Deyo, November 21, 2022.
11: "Gaming Industry Nearly Twice as Large as Reported, at $336B," Naavik, September 15, 2022.

A final tailwind to the expansion of livestream shopping is the growth of m-commerce, which continues to outpace desktop sales.[12] Near-ubiquitous smartphone penetration, expanding 5G coverage, a growing population of digital-native shoppers, and optimized mobile shopping experiences will continue to foster growth. Closely coupled to m-commerce growth is the rise of influencer personalities. Over 90% of Generation Z shoppers credit influencer recommendations as the most important driver in a purchase decision, and three out of four Gen Z shoppers shop online. The majority of this shopping occurs on a smartphone.[13] Despite a return to prepandemic shopping preferences and e-commerce growth rates, m-commerce adoption and the reach of influencers has proven durable.

"Super apps," applications that provide users with core functionality and adjacent, independent mini-apps,[14] including WeChat, Paytm, or Alipay, are one such reason for the popularity of livestream commerce in China. In the West, a disaggregated application landscape has fostered both new startups and native development by technology heavyweights. Notable startups, including emergent leaders such as Whatnot, Shopshops, and Flip, have generated significant capital and deal volume in recent years. 2021 set a record with $1.1 billion in funding, spurred, in part, by the COVID-19 pandemic, which pushed users to experiment with new shopping methods. 2022's funding total took a moderate step back, at $678.6 million across 24 deals. Technology and commerce titans have also entered the fray. TikTok quietly launched TikTok Shop in the US toward the end of 2022,[15] despite shuttering an initial operation in the UK earlier in the summer due to difficult staff working conditions and poor results.[16] Amazon launched its own version of QVC-style shopping in 2019, and Walmart previously announced an ongoing partnership with Talkshoplive.[17]

E-commerce VC deal value ($M)



Source: PitchBook | Geography: Global
*As of December 14, 2022

12: "2020 E-Commerce Payments Trends Report: US," J.P. Morgan, n.d., accessed November 10, 2022.
13: "LTK Study Reveals Influencers Are the Single Most Important Online Purchase Driver for Gen Z Adults," Business Wire, October 19, 2021.
14: "What Is a Superapp?" Gartner, Lori Perri, September 28, 2022.
15: "TikTok Launches E-Commerce Feature in App To Compete with Amazon," Semafor, Louise Matsakis, November 11, 2022.
16: "TikTok Abandons E-Commerce Expansion in Europe and US," Financial Times, Cristina Criddle, July 4, 2022.
17: "Walmart Is Expanding Its Live-Shopping Partnership with Talkshoplive," *Bloomberg*, Brendan Case, February 22, 2022.

Top livestream commerce startups to watch*

Company	Last financing size ($M)	Total VC raised ($M)	HQ country	Reason to watch
Whatnot	$260.0	$485.4	US	Whatnot is a leader in capital raised domestically and focused on limited-edition collectibles.
Firework	$150.0	$279.5	US	Content created with Firework can be embedded into a website or owned digital channel.
Verishop	$84.0	$144.0	US	Verishop focuses on independent brands and helps content creators connect with their followers.
Bambuser	Undisclosed	$99.3	Sweden	Bambuser is the largest European-based livestream commerce startup.
Flip	$60.0	$94.7	US	Flip focuses on beauty and cosmetic items, a natural fit for livestream product demonstrations.
droppTV	$75.0	$90.0	US	droppTV leverages livestream sales at the intersection of entertainment, music, fashion, and culture.

Source: PitchBook | Geography: Global
*As of December 15, 2022

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FOODTECH: CULTIVATED PROTEIN

Outlook: The cultivated protein category will see record funding in 2023 as the US nears regulatory approval.

Rationale: In November 2022, UPSIDE Foods completed the "first pre-market consultation for a human food made from cultured animal cells."[18] The cultivated protein industry saw VC funding more than quadruple following the milestone of Singapore granting regulatory approval to cultivated chicken provider Eat Just. We expect funding to surge once again following the Food and Drug Administration's (FDA's) announcement regarding UPSIDE Foods.

Risks: Alt proteins have not been immune to the cross-industry fundraising challenges arising from the closed IPO window, rising interest rates, and public market volatility. These factors could eclipse the tailwinds of regulatory approval. Public perception is precarious, with few opportunities for consumers to sample cultivated products. Meat industry groups could negatively impact perception through lobbying and messaging efforts. Although the FDA's pre-market consultation was a major milestone for the industry, regulatory steps from the US Department of Agriculture (USDA) remain. That organization is considered more susceptible to political and industry maneuvering, which may lead to commercialization roadblocks for cultivated meat providers.

UPSIDE Foods' FDA pre-market consultation letter marks a major milestone in the commercialization of cultivated meat. Following USDA inspection and label approval, the company will be permitted to sell food in the US. The expected imminent regulatory approval in the US and beyond, combined with the potential environmental, ethical, and health benefits of cultivated proteins and large market opportunities, is expected to drive record investment in 2023.

As discussed in our analyst note Reinventing Meat, cultivated meat promises health and macro benefits. Cultivated meat is more likely to be free of antibiotics, hormones, and zoonotic diseases found in industrial animal meat products. Cultivated meat providers may also design products with enhanced nutritional benefits such as elevated protein and amino acid levels. Cultivated proteins have environmental benefits, including reduced greenhouse gasses (GHGs) and lower land and energy requirements compared with traditional meat production. Cultivated proteins are also bereft of the ethical and animal welfare concerns of conventional animal agriculture.

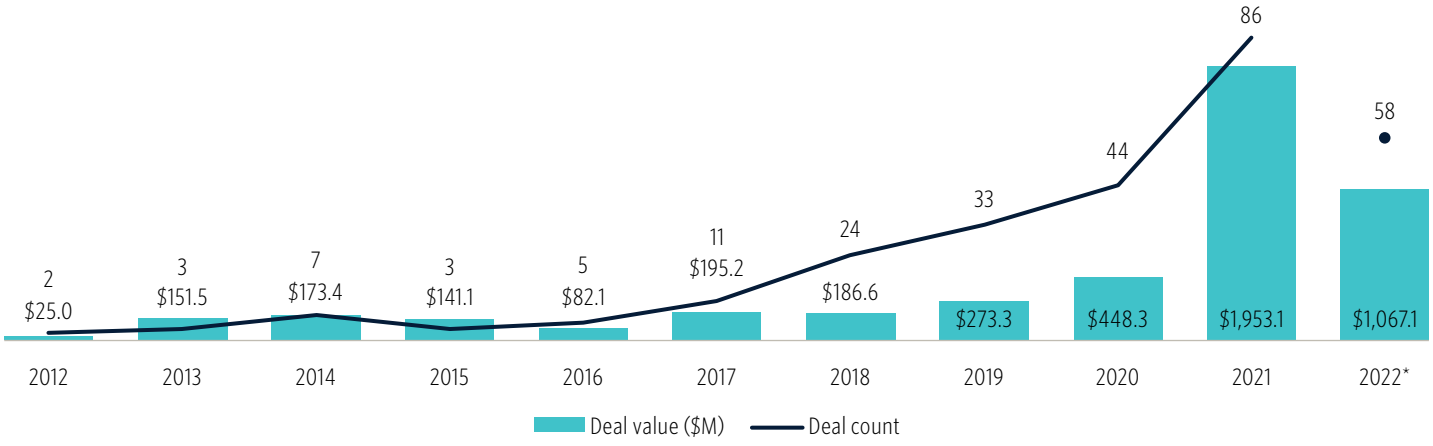
Despite the minimal market history, Boston Consulting Group and Blue Horizon Corporation project the market for cultivated foods—including meat, seafood, dairy, and eggs—to reach approximately $18 billion, or 6 million metric tons, by 2035.[19] The limiting factor will most certainly be supply constraints. Although cultivated protein companies are expanding production capacity, technological limitations currently limit scale.

18: "FDA Completes First Pre-Market Consultation for Human Food Made Using Animal Cell Culture Technology," FDA, November 16, 2022.
19: "Food for Thought: The Protein Transformation," BCG, Benjamin Morach, et al., March 24, 2021.

Cultivated protein providers, including Eat Just, BELIEVER Meats, and BlueNalu, are working through regulatory approvals and have pilot facilities ready to begin production of limited quantities of cultivated meat or fish. These companies will need to scale production by building large commercial facilities to meet demand. BELIEVER Meats recently broke ground on a 200,000-square-foot production facility in North Carolina that will be capable of producing 22 million pounds of meat annually.[20] BlueNalu currently has a 38,000-square-foot production facility and plans to build a larger 140,000-square-foot facility.[21] Venture capital will likely play a critical role in funding these efforts.

Much of the inputs and infrastructure for manufacturing cultivated protein are sourced from medical equipment and biopharmaceutical ingredient suppliers. These inputs are too costly and produced in quantities too limited to meet profitability and supply requirements in the food industry. A dedicated pick-and-shovel ecosystem has formed over the past five years, with startups developing growth media, scaffolding, and bioprocessing equipment designed for the scale and cost requirements of the cultivated meat industry. Further innovation will help tackle the most critical challenges of reducing manufacturing costs and increasing supply.

Cultivated protein VC deal activity



Source: PitchBook | Geography: Global
*As of September 30, 2022

20: "Press Release: BELIEVER Meats Breaks Ground on Largest Cultivated Meat Production Facility in The World," BELIEVER Meats, December 7, 2022.
21: "Press Release: BlueNalu Cracks the Code to Significant Profitability in First Large-Scale Facility," BlueNalu, October 5, 2022.

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INFORMATION SECURITY

Outlook: Information security leaders will make multiple data security acquisitions.

> **Rationale:** Data security is becoming an increasing priority for organizations and an emerging threat surface with the rise of cloud databases.
>
> **Risks:** Data security is not the largest category of information security, and past tendencies suggest that incumbents will protect access to the data rather than building a data loss prevention product.

Information security (infosec) incumbents are consolidating their market leadership through horizontal integration. Leading information security investor Dave DeWalt, former CEO of McAfee, expects a group of "titans" to continue acquisition strategies in a financial downturn to own more of the infosec stack.[22] We have tracked continued acquisition activity during 2022, including a return to high activity from leading acquirer Palo Alto Networks, which made a $300.0 million acquisition of Cider Security. We believe the startup ecosystem is ripe for consolidation, with leading unicorns facing pressure on revenue growth from more judicious buyers.

Data security remains an outstanding segment for most infosec incumbents that have focused on more surface-level defenses on endpoints. With applications increasingly communicating directly with cloud databases, endpoint and network controls can miss data exfiltration and poisoning. DeWalt and fellow infosec investing leader Bob Ackerman from AllegisCyber see data-focused attacks presenting a looming threat vector over the coming year and view current solutions as insufficient to deal with malicious data injections and manipulation. Database adoption remains robust, as evidenced by continuing high revenue growth for Snowflake and Databricks. For data users, data security ranked as the highest area for investment in an IDC survey, above analytics and AI automation.[23]

Data security can complement infosec leaders' horizontally integrated product portfolios. Leaders have not historically focused on data security, given the mature market for data loss prevention and the segment's status as a last line of defense that does not prevent breaches. In Q4 2021, CrowdStrike acquired SecureCircle for $68.0 million. SecureCircle brings data loss prevention to endpoints with identity-based policies. According to company estimates, the acquisition increased CrowdStrike's total addressable market by $3.6 billion, which is consistent with our estimate in our Q2 2022 Information Security Report.[24] Other incumbents have not recently made acquisitions in the segment, instead focusing on application security, network security, and security operations. The market downturn may have halted a trend started by CrowdStrike, which can revive once deal value expectations align in 2023.

22: Dave DeWalt, former CEO of McAfee, interview by Brendan Burke, November 28, 2022.
23: "IDC FERS Survey Identifies Cybersecurity as a Top Investment Priority in the Future of Industry Ecosystems," IDC, January 25, 2022.
24: "Corporate Overview," Crowdstrike, November 2022.

Promising technologies to acquire include encryption and cloud database protection. A new category of data detection & response is emerging in response to direct exploits against cloud databases, thus creating a new category of telemetry that incumbents may lack. Further, advanced encryption techniques can apply recent protocols to data as it moves through cloud, databases, and applications. We have tracked high momentum for data security startups in 2022, including Immuta, Baffle, Titaniam, and Dig Security. A pipeline of acquisition targets may be emerging in an overlooked category.

Infosec market leader acquisitions by segment (2020-2022)*

Infosec market leader	Application security	Data security	Endpoint security	Identity & access management	Network security	Security operations
Alphabet						Foreseeti ($6.3M) Siemplify ($500M)
CrowdStrike		SecureCircle ($60.8M)		Preempt Security ($91.2M)		Reposify
Fortinet					OPAQ ($8.0M) ShieldX ($10.8M)	
Okta				Auth0 ($5.7B)		
Palo Alto Networks	BridgeCrew ($156.9M) Cider Security ($300.0M)					Expanse ($797.2M)
Microsoft			Refirm Labs	CloudKnox		RiskIQ ($500.0M)
Rapid7	Alcide ($50.5M)				IntSights ($322.2M)	
SentinelOne					Attivo Networks ($616.5M)	
Zscaler					Cloudneeti ($8.9M) Trustdome ($31.1M)	

Source: PitchBook | Geography: North America & Europe
*As of November 30, 2022

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INSURTECH

Outlook: Insurtech VC investment will reach a five-year low.

> **Rationale:** 2022 saw a significant slowdown in insurtech VC activity, particularly in the second half of the year. A lack of venture exits, lower public valuations, and a pullback in spending from insurers and their VC arms drove this slowdown. With increasing market uncertainty and subpar profitability within the insurance sector, the contraction is expected to continue.
>
> **Risks:** The insurtech market peaked in early 2021—earlier than the rest of the tech market. Investors may feel that the insurtech market has now bottomed out and that valuations are attractive. This will potentially lead to an increase in investment capital across both the public and private markets.

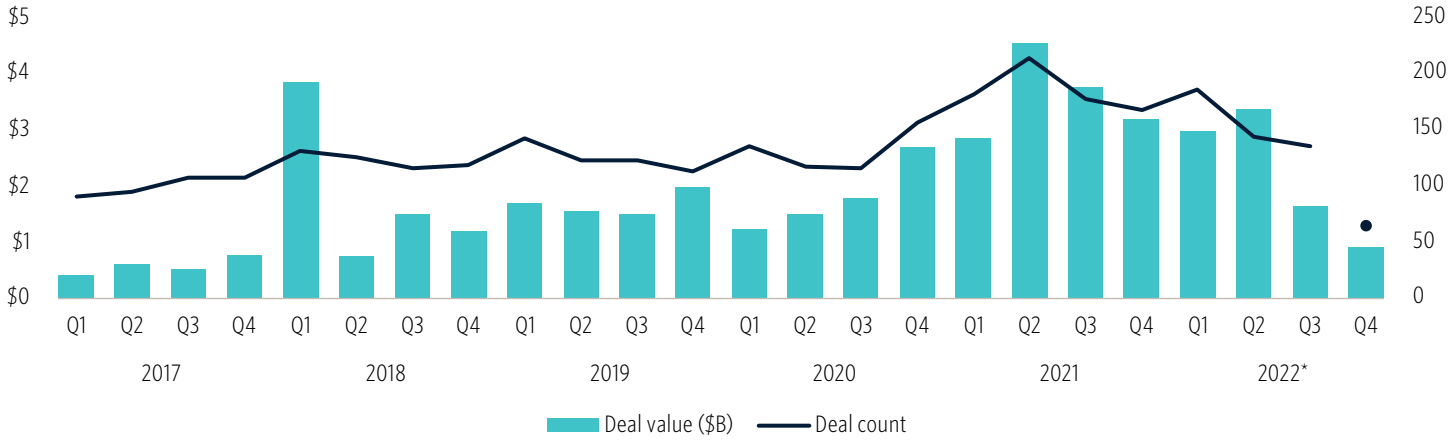
2021 was a record year for insurtech companies, which raised $14.3 billion in VC across 736 deals globally. This record was fueled by capital surpluses in venture capital and an accelerated pandemic-driven shift toward digitalization. Further, robust IPO markets in the recent past led to successful insurtech exits such as Lemonade, Oscar, Root, Bright Health, and PolicyBazaar. This robust exits market returned meaningful capital to venture capitalists and LPs, with many investors doubling down and redeploying capital into the insurtech space. In 2022, most of these trends reversed as capital availability tightened and IPO markets virtually shut. This has led to a significant decrease in VC investments for the year, which we believe will not eclipse $10 billion before the year's end. The capital deceleration is more pronounced in Q3 and Q4 so far, with only $1.6 billion and $923.0 million invested, respectively. These figures represent quarterly lows not seen since Q1 and Q2 2020, when the pandemic began to rattle the markets. Further, insurance corporate VC (CVC) arms—which invested heavily in insurtech companies over the past few years—participated in only 77 deals in 2022 on an annualized basis, compared with 117 deals in 2021. The aggregate value of deals with CVC participation also fell to an annualized $2.9 billion in 2022 from $6.7 billion in 2021.

We expect these investment trends to continue in 2023 and lead to the lowest amount of VC invested into insurtech companies since 2017, when less than $7 billion was invested. A pullback in investments from incumbent insurers will lead to pervasive effects across the insurtech space. While insurance carriers have been resilient during the past couple of years—overcoming the pandemic, war and geopolitical tensions, and rising inflation—significant challenges on the horizon, including market volatility, an economic recession, and climate change, will compel insurers to increase their cost-cutting efforts. As mentioned above, insurers have already reduced VC investments, but many have also limited acquisitions of insurtech companies in 2022, thus opposing what we predicted would occur this year. Along with closed IPO markets, this reduction in acquisitiveness will severely limit the exit opportunities available to insurtech companies.

As the capital runway shortens, many insurtech companies will be forced to raise VC at down rounds, get acquired at a discount, or shut down altogether. Any of these scenarios will lower VC and LP appetite for insurtech startups. Although we

expect lower insurtech investment activity in 2023, opportunities for investments will remain, including enablement technologies that lower distribution costs, enhance underwriting, or automate claims. Startups developing technologies in these areas are also possible strategic acquisition targets for insurers looking to increase efficiencies to further cut operational costs and loss-adjustment expenses. Meanwhile, other areas of insurtech that directly sell risk, including cyber, pet, and specialty, remain attractive opportunities, as these are newer markets with fewer incumbent competitors.

Insurtech VC deal activity by quarter



Source: PitchBook | Geography: Global
*As of December 5, 2022

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INTERNET OF THINGS

Outlook: Smart home VC funding will regress below 2020 levels.

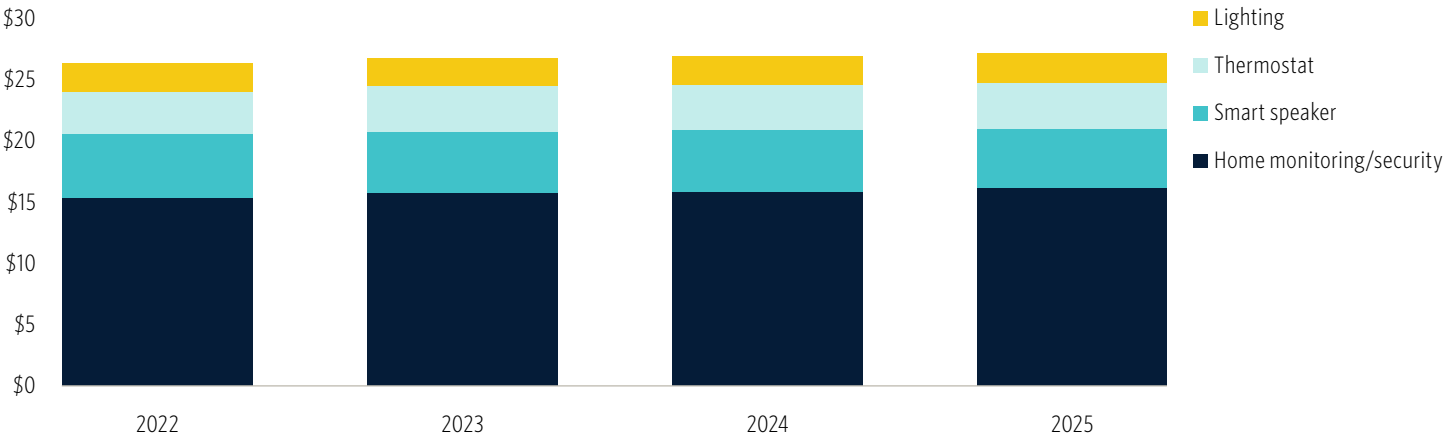
Rationale: Smart home startups face pressure from a pending recession, the whiplash effect from the pandemic, and strengthened standards for incumbent devices. Even so, smart home VC funding has remained high in 2022 despite low growth in the segment overall. The market size remains large, yet is increasingly captured by Big Tech companies.

Risks: Tech giants remain committed to smart home and may make investments to keep VC funding high. Energy efficiency devices may benefit from a recession, and some of the largest startups address that opportunity.

Smart home was the second-highest-funded category in IoT in H1 2022 despite having the lowest growth rate among all categories. The category raised over $1 billion in VC, establishing a pace to surpass all previous annual totals before 2021. In aggregate, VC has continued to outpace 2020's totals even as public market valuations fall back in line with pre-pandemic levels, suggesting that VC funding will continue to grow for high-value technologies. However, the smart home industry faces additional headwinds compared with pre-pandemic conditions, with lower M&A activity, lower growth, and increasing industry standardization creating barriers to growth.

Due to economic headwinds, smart home technologies are on pace to achieve low growth over the next three years. The smart speaker area may be saturated, as declines are likely from current sales levels. Amazon's reduced commitment to the Alexa technology demonstrates the limits to growth in this segment.[25] Other key categories, including security monitoring, lighting, and thermostats, should maintain low-single-digit growth, thereby limiting opportunities for high-growth VC-backed businesses to capture share. Overall, we do not expect the smart home market to grow significantly over the next three years, but other categories of the IoT market will grow above 15%.

Smart home market size estimate ($B) for leading product categories*



Source: IDC | Geography: Global
*As of October 31, 2022

25: "As Amazon's Alexa Unit Faces Layoffs, Insiders Describe a Department in Crisis," *Business Insider*, Jordan Parker Erb, November 21, 2022.

The emerging Matter standard promises to favor incumbents, thus lowering the value of startups with interoperability solutions. The Matter smart home standard unites devices from multiple manufacturers with a common networking signal under the Zigbee protocol. This shared protocol changes the patchwork of frequencies previously used by manufacturers that made their devices incompatible with competitors'. This standard was released by the Connectivity Standards Alliance in October 2022. Contributors to the standard include Amazon, Apple, Google, LG, and Samsung, which all rank among the market leaders in smart home device shipments. The standard applies retroactively to most existing devices, thereby enhancing the value of legacy hardware.

Startups face pressure to continue scaling, given micro and macro headwinds. The one smart home acquisition we tracked in H1 2022 was for IOTAS, a startup that integrates smart home devices within a single apartment with a common control plane. The need for solutions like these has diminished with the launch of the Matter standard, given the interoperability offered by tech giants. Headwinds from the Matter protocol may have led to a reduced growth outlook and made IOTAS' technology more valuable as part of a device distributor's portfolio. Other smart home connectivity startups face similar headwinds to gaining scale. Device startups will find that customers are less willing to replace their existing devices due to added value from improved connectivity standards.

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MOBILITY TECH

Outlook: There will be a broad-based wave of consolidation across the mobility tech vertical.

Rationale: Over the past five years, an unprecedented amount of capital flowed into the mobility tech vertical, pursuing autonomous driving and associated systems, electric vehicles, and last-mile delivery. During the past year, as the IPO window closed and share prices of many recently public mobility tech companies plummeted, investors have pulled back. Many startups have taken steps to conserve cash and cut costs, and we have yet to see a meaningful uptick in down rounds. For many startups that struggle to raise new capital, consolidation will likely provide the most viable means to move forward.

Risks: Startups demonstrating solid revenue growth and a path to profitability will likely attract investor attention over the near to medium term. The successful public listing—albeit at a significantly lower valuation than anticipated just one year ago—of Mobileye in November demonstrates that startups with growing revenue streams and attractive margins can garner positive investor attention in this environment.

In our most recent Emerging Technology Indicator, which tracks investments from the top venture capitalists and accounts for approximately 10% of all venture investments, VC activity in the mobility tech vertical compared with 30 other verticals rated dead last. Numerous recent IPOs from the vertical have fallen more than 90% since listing. The massive wave of capital that flowed into autonomous driving startups over the past several years has ground to a halt as investors digest events such as Ford and Volkswagen shuttering Argo.ai. A recent Bloomberg article detailed how Apple has dialed back ambitions for launching a fully autonomous car and now appears poised to release a more traditional vehicle with a steering wheel and typical controls with the potential for remote operation.[26] In electric vehicles, supply chain and materials constraints for batteries, semiconductors, and other parts have resulted in startups pushing out production plans just as traditional auto original equipment manufacturers (OEMs) are ramping production of their electric vehicle programs.

The market capitalization of several public mobility tech startups has plummeted below the level of cash on their balance sheets, thus leaving them vulnerable to take out and liquidation. Several have acquired significant domestic manufacturing facilities, which may prove attractive to acquirers looking to establish domestic footholds in light of recent US moves toward industrial policy and advantageous taxation and subsidies for domestic manufacturing. Foxconn, better known as the contract manufacturer for Apple's iPhone, recently increased its stake in Lordstown Motors after acquiring Lordstown's Ohio vehicle assembly plant, which was previously a General Motors automobile factory from 1966 to 2019.[27] Wejo and Otonomo, previously rivals in the automotive data aggregation and analytics segment, are reportedly in talks to merge. Both had gone public in recent years and now trade below $1 per share. Also, in November, Velodyne Lidar, which developed the original lidar technology used in autonomous vehicle development, announced plans to merge with rival Ouster. Absent further infusions of cash, we expect consolidation activity among mobility tech startups to increase in coming months.

26: "Apple Scales Back Self-Driving Car and Delays Debut Until 2026," *Bloomberg*, Mark Gurman, December 6, 2022.
27: "Lordstown Motors and Foxconn Broaden Strategic Partnership," Lordstown Motors, November 7, 2022.

Recent mobility tech IPOs*

Company	Ticker	Share price	YTD performance	Most recent quarter balance sheet cash per share
Rivian	RIVN	$25.70	-73.7%	$14.46
TuSimple	TSP	$1.88	-95.2%	$5.16
Embark Trucks	EMBK	$3.07	-98.2	$8.23
Lordstown Motors	RIDE	$1.38	-60.3%	$0.94
Lucid Group	LCID	$8.20	-77.2%	$1.99
Otonomo	OTMO	$0.50	-87.8%	$0.92
Archer Aviation	ACHR	$2.14	-64.6%	$2.52
Joby Aviation	JOBY	$3.71	-51.9%	$1.76

Source: PitchBook | Geography: Global
*As of December 12, 2022

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RETAIL FINTECH

Outlook: The digital banking sector will begin to see higher levels of industry consolidation.

Rationale: Neobanks, also known as challenger banks or digital banks, received record levels of funding in 2021 due to federal stimulus and favorable macroeconomic conditions; however, roughly 95% of these digital banks have yet to achieve profitability.[28] Currently, even the largest and most well-known neobanks have yet to demonstrate a clear path to an attractive return on equity. This is due largely to neobank revenue models' reliance on interchange—or swipe—fees, which leaves revenues highly susceptible to shifts in transaction volumes. As such, we expect it will be difficult for subscale businesses to achieve profitability in the short term, especially as consumer spending comes under further pressure from inflation.

Accounting for a one-dimensional business model, higher costs of capital, declining consumer spending, and shifting investor focuses from growth to profitability, we expect many smaller players in the digital banking space to encounter difficulty securing additional capital. Further, valuations have continued to mean-revert from 2021's record levels, thus bolstering the attractiveness of acquisition opportunities. As startups seek additional growth runways and incumbents further consider "buys" over "builds," we expect a material uptick in industry consolidation.

Risks: Valuations are still level-setting; thus, potential incumbents and acquirers could continue to wait to see how market conditions unfold. Additionally, factors such as market sentiment, higher operating expenses, and more constrained investment capital have negatively impacted the valuations and bottom lines of many financial institutions. This could lead to shifts in capital allocation strategies, in which M&A may become a lower priority. Still, well-capitalized financial institutions are positioned to go on the offensive and acquire.

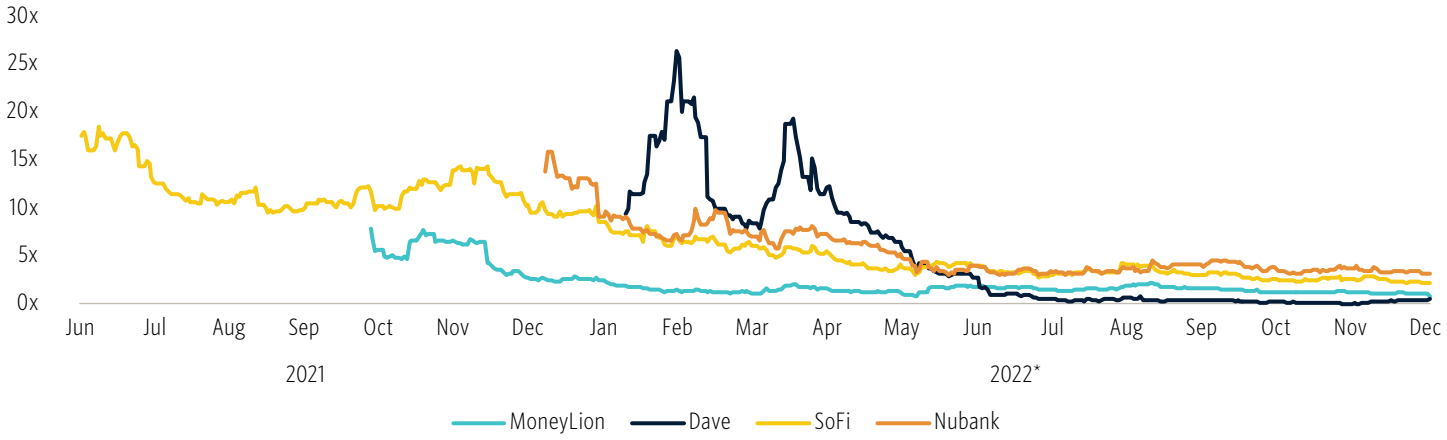
In 2021, digital banks received $11.1 billion in VC funding, the highest level of VC deal activity within retail fintech. This immense flow of capital into the digital banking space was due largely to trillions of dollars in US government stimulus, further supported by cheaper costs of capital and historically low interest rates. Government stimulus also resulted in higher levels of consumer wealth, while pandemic-induced shutdowns accelerated the adoption of digital banking products. However, real consumer spending would likely decline if a recession were to occur.

As of Q3 2022, digital banks have received $3.0 billion in funding for the year, highlighting a reversal of the robust funding environment witnessed in 2021. Certain neobanks will likely become constrained for capital, as they burn through cash, VC investment declines, and interest in neobanks wanes. Financial data from large challenger banks provides additional insight into the performance of digital banks. Varo, which last raised a $510.0 million Series E in September 2021, currently holds equity capital of $181.1 million and recognized a net loss of $42.5 million in Q3. A similar narrative is seen when observing Varo's holding company, Varo Money, Inc., which recorded a net loss of $162.0 million and total equity capital of $231.7 million in Q2. Looking at public neobanks, Dave

28: "Less Than 5% of the World's 400 Neobanks Are Profitable," *Fintech News Singapore*, June 27, 2022.

has seen its valuation decline to 0.2x next twelve months (NTM) EV/sales compared with 9.4x at the start of 2022; it recorded a net loss of $47.5 million, with $223.9 million cash on hand—comprised of $185.3 million in short-term investments—in Q3. Similarly, MoneyLion now trades at 1.0x NTM EV/sales compared with 2.4x at the beginning of 2022, and it reported a net loss of $21.0 million in Q3, with $126.4 million of cash.

EV/NTM sales multiple by month



Source: PitchBook | Geography: Global
*As of December 1, 2022

Efforts to prolong operations are additionally evidenced by recent actions by several neobank and banking-as-a-service (BaaS) startups to lower expenses by reducing headcount. Examples of layoffs implemented in 2022 include those from Chime, which laid off roughly 12% of staff;[29] Varo, at roughly 10% of staff;[30] Step, at roughly 11%;[31] and Synctera, at roughly 13%.[32] However, bright spots remain in the industry, with neobanks such as Nubank, Starling, and Atom Bank delivering profitable bottom lines and retaining their employees.

Despite over 150 new digital banks created in the last two years,[33] acquisitions of digital banks have been infrequent thus far. However, large industry players have historically demonstrated willingness to acquire fintech companies, and we expect this could accelerate as valuations become more attractive. Key acquisitions since 2021 include Walmart's acquisition of ONE, Avant's acquisition of Level, Bunq's acquisition of TriCount, and Oportun's acquisition of Digit. Notably, these acquisitions were driven by the intent of the acquiring companies to create a single ecosystem of products that assists consumers in managing and utilizing their money, which would ultimately create additional cross-selling opportunities.

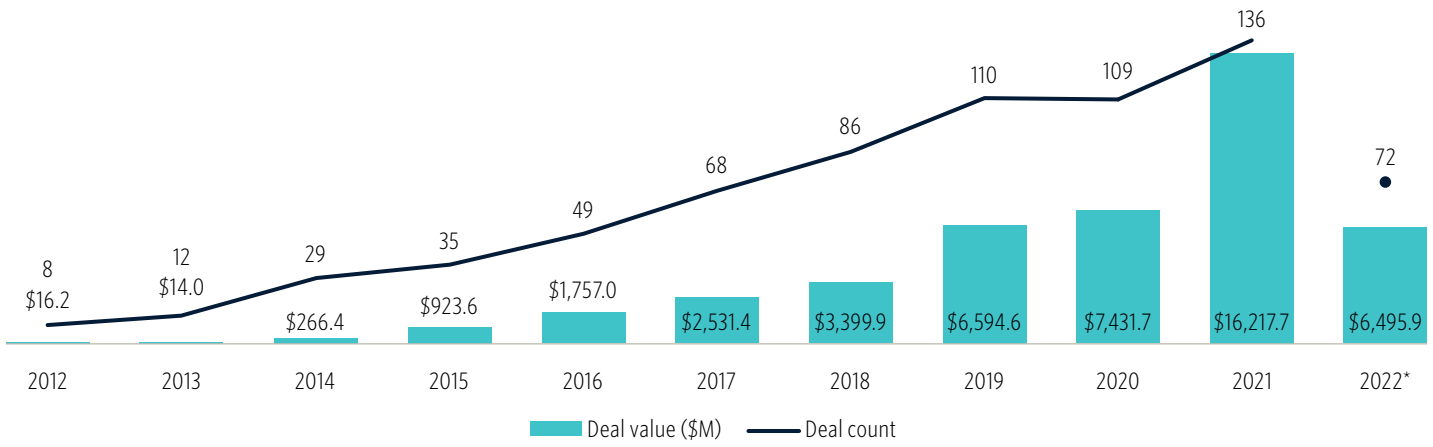
Large industry players and incumbents could also look to acquire startups in the digital banking sector in order to expand their customer bases and integrate new technologies. For example, over the past two years, big financial institutions such as JPMorgan Chase and SoFi have demonstrated their willingness to acquire fintech startups in efforts

29: "Chime Is Cutting 12% of Its Staff," Protocol, Ryan Deffenbaugh, November 2, 2022.
30: "Varo Cuts 10% of Staff as Digital Bank Restructures To Achieve Profitability," *Forbes*, Dylan Sloan, July 20, 2022.
31: "The Unfortunate Year of Layoffs," LinkedIn, Arjun Vir Singh, August 1, 2022.
32: "In Fintech, 2022 Is Becoming the Year of Layoffs," Head Topics, Jeff Kauflin, August 1, 2022.
33: "Banks Finding New Banking-As-a-Service Customers as Neobanks Pull Back," S&P Global, Yizhu Wang and Umer Khan, August 30, 2022.

to enhance their ability to cater toward consumers. Since 2020, JPMorgan Chase has completed several acquisitions of fintech companies, with the most notable including payments startup Renovite; environmental, social, and governance (ESG) investing platform OpenInvest; tax-smart investment platform 55ip; and robo-advisor Nutmeg. Similarly, SoFi has previously acquired multiple startups, including consumer credit platform Lantern Credit, payment processing platform Galileo, and digital banking software developer Technisys.

Regarding neobank insolvencies, we have recently seen examples from Nirvana Money, GloriFi, Nuri, and Nearside (Hatch), all of which have exited operations over the past two months. The shutdown of these businesses reflects that these particular banks were challenged and that there is possibly limited availability of capital from investors. Furthermore, the inability of these startups to stay afloat suggests that these banks were unsuccessful in securing additional funding rounds or finding acquirers, which could indicate that potential buyers may still be waiting out the market before deploying capital for acquisitions.

Credit and banking VC deal activity



Source: PitchBook | Geography: Global
*As of September 30, 2022

Key digital banking acquisitions since 2021*

Target company	Acquirer(s)	Deal date	Acquisition size ($M)
ONE	Hazel Fintech (Walmart)	April 5, 2022	N/A
Level	Avant	April 7, 2021	N/A
86 400	National Australia Bank	May 19, 2021	$220.0
bnc10	Synthetic Neural Labs	July 16, 2021	N/A
0.5Bn FinHealth	Avail Finance	November 18, 2021	N/A
Finin	Open	December 14, 2021	$10.0
Digit	Opportun	December 22, 2021	$205.3
Tricount	Bunq	May 3, 2022	N/A

Source: PitchBook | Geography: Global
*As of December 1, 2022

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SUPPLY CHAIN TECH

Outlook: Remote operations will scale up as investors and entrepreneurs pull back from efforts in autonomous vehicles and delivery.

Rationale: 2022 has seen investment and enthusiasm wane for autonomous vehicles. With billions of dollars invested and after several years of expectations that autonomous vehicles were just over the horizon, 2022 marked a sea change in which several key players scaled back or shuttered investments altogether. Ford and Volkswagen pulled the plug on Argo.ai in October, with Ford's CEO Jim Farley stating that "profitable, fully autonomous vehicles at scale are a long way off and we won't necessarily have to create that technology ourselves."[34] Ford is instead focusing its efforts on advanced driver assistance systems that keep a human in the loop. In terms of the supply chain vertical, wherein billions of dollars have been invested in autonomous last-mile delivery, freight, and materials handling, we see the potential for investors and entrepreneurs to pivot toward remote operations systems to overcome some of the technical difficulties of autonomy while still delivering many of the benefits to customers. This past fall, Amazon shut down Scout, its home delivery robot project, and FedEx announced that it curtailed development of Roxo, its last-mile delivery autonomous system. These two industry leaders obviously see the promise of autonomous delivery, but their actions underscore that it's not quite there yet.

Risks: Ford, Volkswagen, and other investors that are now balking at autonomous driving may be making a mistake, and Waymo and General Motor's Cruise, the two most prominent players left standing, could achieve breakthroughs that cement an insurmountable lead. Ford and Volkswagen certainly have the capital to continue to pursue the endeavor, but Farley's concerns about scale and profitability belie something lacking in the ability to commercialize the technology on a reasonable investment horizon. Also, remotely operated solutions as fully autonomous systems may face similar regulatory hurdles and pushback from labor and other stakeholders.

Autonomous systems in supply chains hold great promise. The American Trucking Association estimates that the truck driver shortage in the US will remain near a historical high in 2022 at nearly 78,000 drivers, and given current demographics and other factors, that number could surpass 160,000 by 2031.[35] What's more, federal regulations stipulate that truckers rest 10 hours within every 24-hour window while on the road.[36] Autonomous driving in trucking, therefore, could spur a significant boost in productivity and freight throughput. Last-mile delivery is another area that could benefit tremendously from autonomous vehicles. For well-defined tasks in structured environments, autonomous systems shine. As numerous warehouse automation and neighborhood delivery systems have proven, however, when confronted with edge cases, the systems often stumble. Unfortunately, on a typical delivery route or freight run, there can be many edge cases, including abnormal

34: "Argo AI, Ford's Self-Driving Venture with Volkswagen, Is Shutting Down," *Forbes*, Alan Ohnsman, October 26, 2022.
35: "ATA: Truck Driver Shortage Remains at Near-Record High," The Trucker, The Trucker News Staff, October 27, 2022.
36: "Summary of Hours Service Regulations," FMCSA, n.d., accessed December 1, 2022.

conditions such as adverse weather, emergency maneuvers, and work zones. The volume of data and computing power needed to attempt to manage such situations is immense. Estimates suggest a level-5—or full autonomy—system would generate somewhere between one and 20 terabytes of data per hour.[37] Nvidia's DRIVE Orin system-on-chip (SOC) runs at 254 trillion operations per second, and its next generation DRIVE Thor SOC targeting 2025 vehicles is slated to provide 8x that performance.

The data and computing statistics are staggering, but these systems still stumble when confronting issues human drivers face and manage every day. Over the near to medium term, given the more restrictive funding environment and emphasis on conserving capital and driving faster toward profitability, we expect to see a number of participants in the industry look to remote operation as a means to leverage existing investments in autonomous operation, with "humans in the loop" to manage the edge cases. Humans, it turns out, come well-equipped to filter irrelevant noise, and with modest training and attention, can easily navigate through myriad edge cases. And our brains manage this on only 12 watts of power, which is a tiny fraction of what's needed to power today's advanced SOCs and machine learning training.

Einride just secured $500 million in funding to ramp development of its uncrewed freight delivery systems. Meanwhile, autonomous trucking startups TuSimple and Embark Trucks are struggling with share prices, which are down more than 95% for the year-to-date period. Built Robotics has created systems that work with heavy equipment such as excavators from brands including Caterpillar, Komatsu, and Hitachi. The company's kits enable robotic operation but also allow manual oversight at the flick of a switch, thus letting operators step in to manage unique situations and difficult operations. Phantom Auto has created a remote operations platform that allows an operator based thousands of miles away to drive forklifts, pallet movers, yard trucks, and delivery robots. Leveraging aspects of autonomous operation, one remote operator can supervise numerous vehicles and step in as needed to resolve edge cases on demand. The founders launched the company with the mission of decoupling labor from location in logistics—a strategy that serendipitously dovetails with the groundswell of remote work in the wake of the COVID-19 pandemic.

37: "Billions of Miles of Data: The Autonomous Vehicle Training Conundrum," CloudFactory, Paul Christianson, September 30, 2020.