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ARK INVEST

January 25, 2022

Annual Research Report | For Informational Purposes Only

Risks of Investing in Innovation

Please note: Companies that ARK believes are capitalizing on disruptive innovation and developing technologies to displace older technologies or create new markets may not in fact do so. ARK aims to educate investors and seeks to size the potential investment opportunity, noting that risks and uncertainties may impact our projections and research models. Investors should use the content presented for informational purposes only, and be aware of market risk, disruptive innovation risk, regulatory risk, and risks related to certain innovation areas.

Please read risk disclosure carefully.

→ **Aim for a cross-sector understanding of technology and combine top-down and bottom-up research.**

→ **Aim to understand the regulatory, market, sector, and company risks. (See Risk and Disclosure Page)**

Source: ARK Investment Management LLC, 2021

Big Ideas 2022: Change & Convergence

When has investing not been about the future?

Change appears to happen slowly and then all at once. Over time, innovation should displace industry incumbents, increase efficiencies, and gain majority market share. With the right understanding of disruptive innovation and a long-term time horizon, we believe investors will capture exponential growth opportunities, which deserve a strategic allocation in their portfolios. For this reason, ARK focuses on opportunities likely to scale as technologies converge, transforming entire industries.

To enlighten investors on the impact of breakthrough technologies we began publishing Big Ideas in 2017. This annual research report seeks to highlight our most provocative research conclusions for the coming year. We hope you enjoy our Big Ideas for 2022.

Source: ARK Investment Management LLC, 2021

Source: ARK Investment Management LLC, 2021

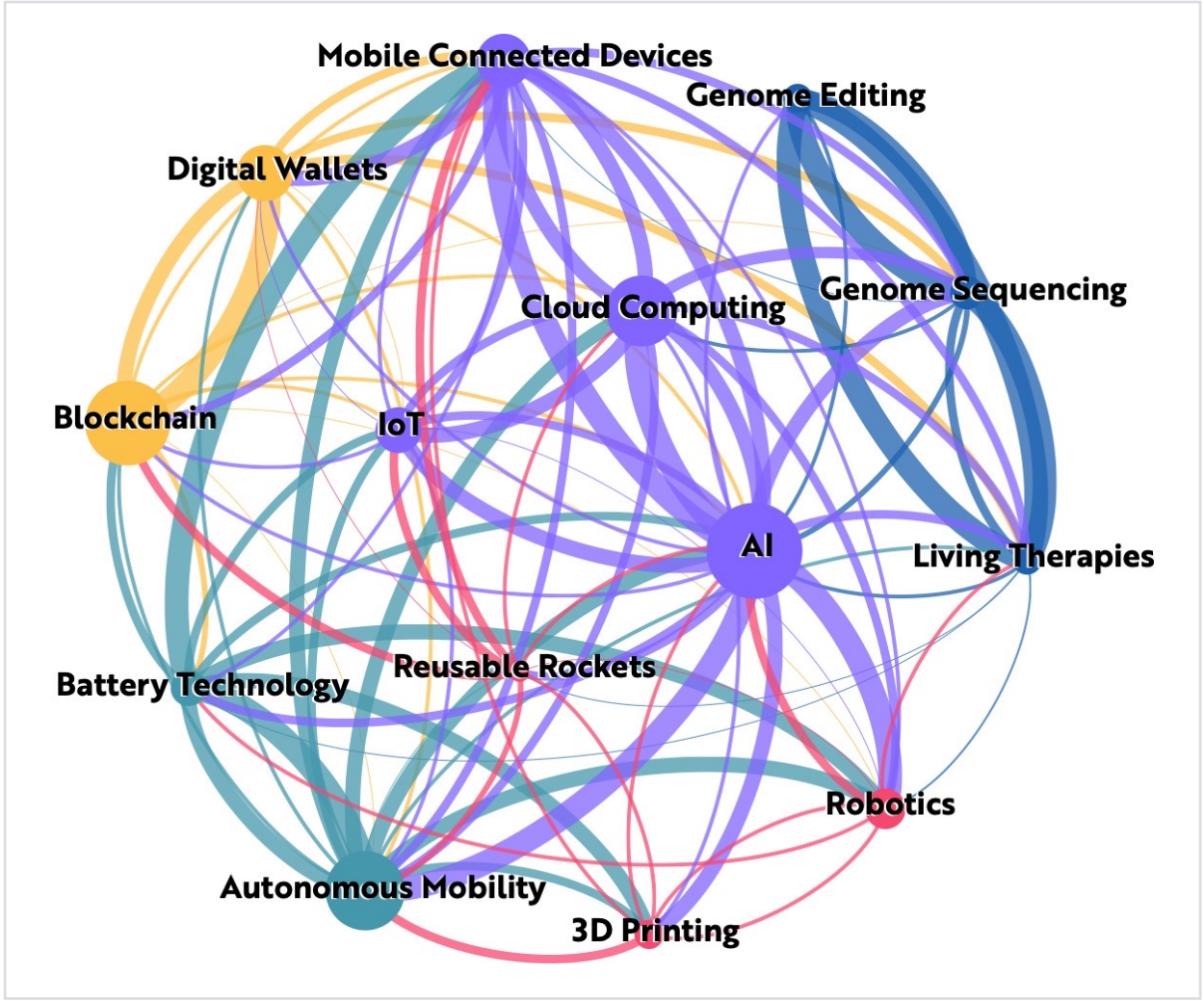
Technologies Are Converging

Brett Winton, Director of Research

ARK's research is centered around the belief that five innovation platforms are evolving and converging at the same time: **Artificial Intelligence, Robotics, Energy Storage, DNA Sequencing, and Blockchain Technology.**

We identified 14 transformative technologies that are approaching tipping points as costs drop, unleashing demand across sectors and geographies and spawning more innovation.

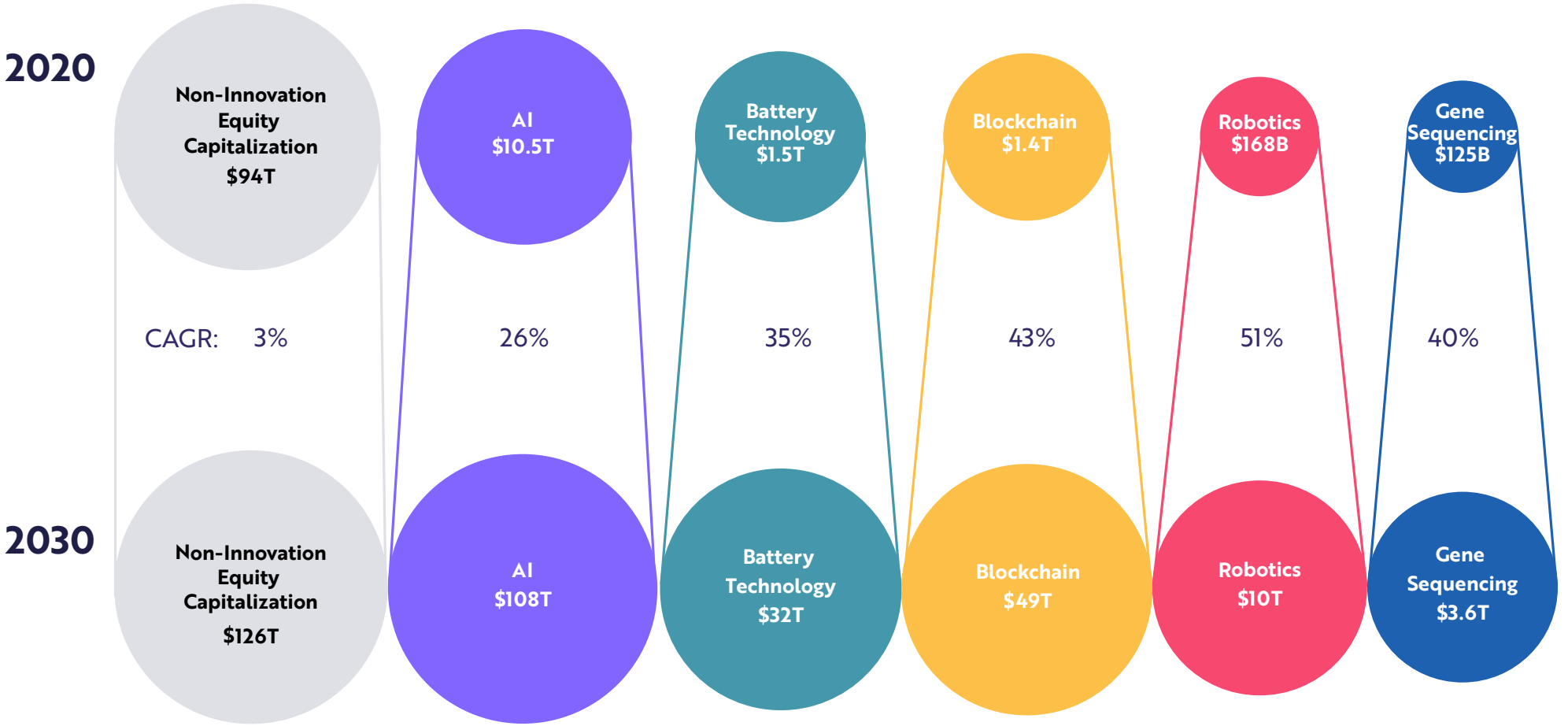
We believe that historians will look back on this era as one of unprecedented technological foment—and they will say: everything changed.

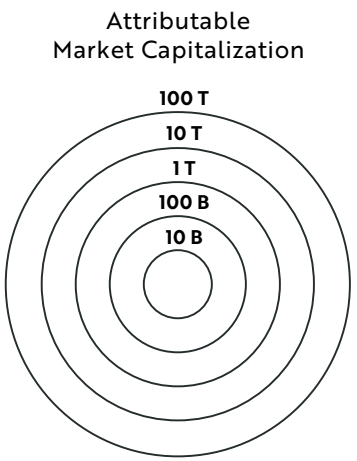


Node Size: Log Prospective 2030 Market
Edge Size: ARK Convergence Score
Color: Innovation Platform

Forecasts are inherently limited and cannot be relied upon. | For informational purposes only and should not be considered investment advice, or a recommendation to buy, sell or hold any particular security/cryptocurrency.
ARK Investment Management LLC, 2021. Forecast is compilation of forecasts for the 14 technologies that ARK defines as underlying the 5 innovation platforms. Assumes that traditional equity market exposures continue to compound value at a rate in excess of inflation and are not substantially disrupted or marked down by negative exposure to innovation. Cryptoassets are likely to be increasingly considered a different asset class by many; comparisons between cryptoasset values and equity market capitalization are cross-asset comparisons. Numbers rounded.
Source: World Federation of Exchanges, ARK Investment Management LLC, 2021.

We Believe That Five Innovation Platforms Will Generate Significant Equity Market Returns Over The Long Term

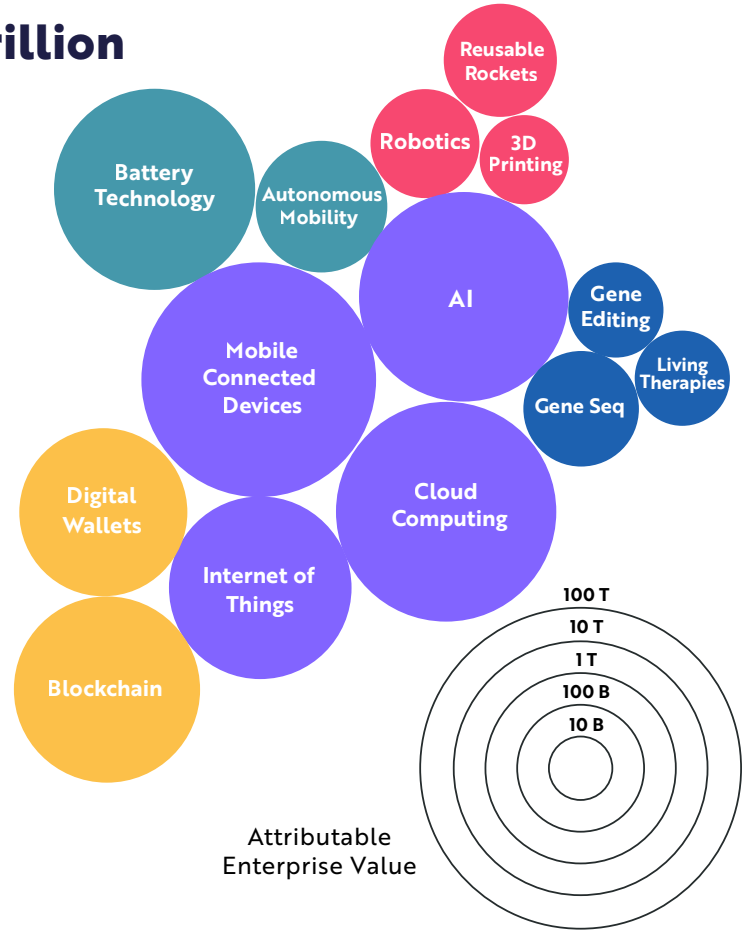




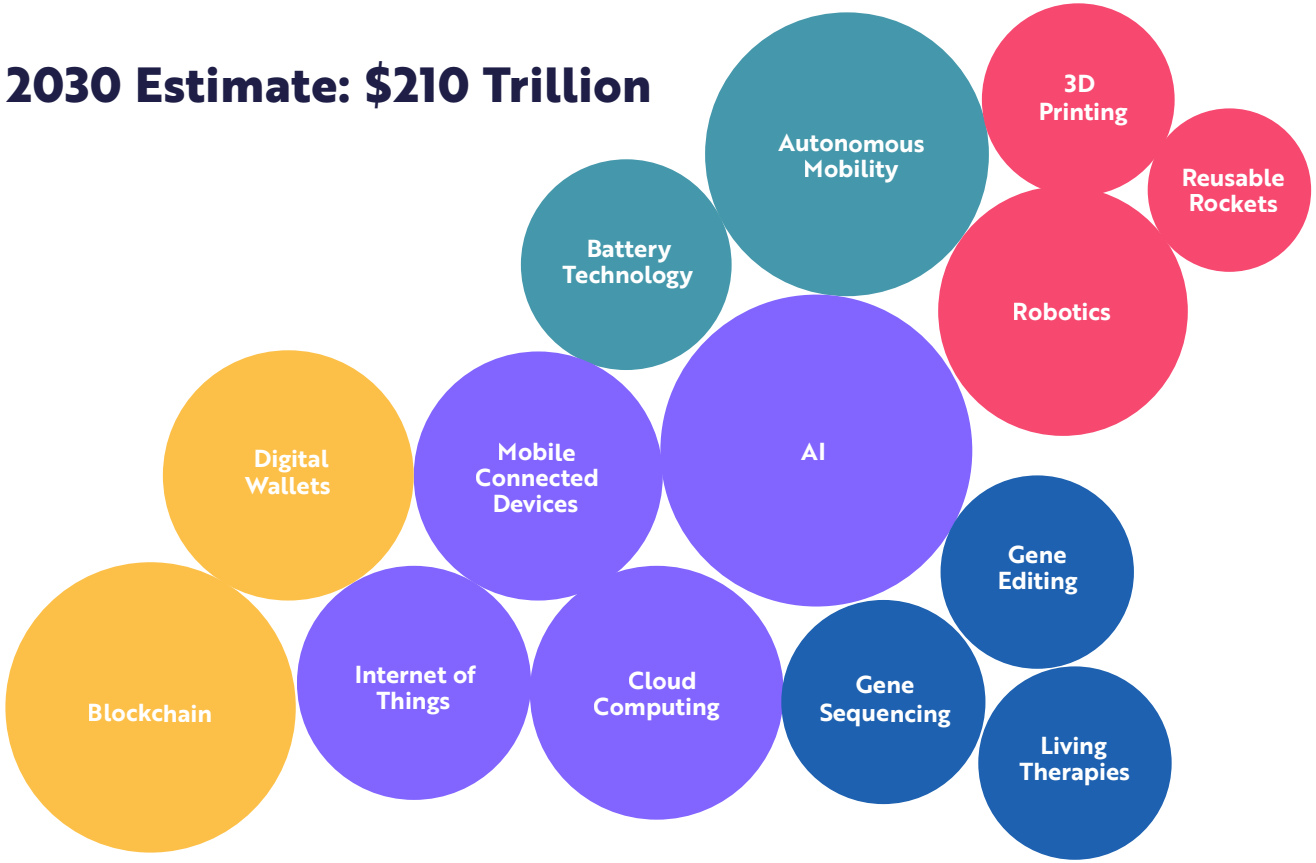
CAGR: Compound Annual Growth Rate | Forecasts are inherently limited and cannot be relied upon. | For informational purposes only and should not be considered investment advice, or a recommendation to buy, sell or hold any particular security/cryptocurrency. | ARK Investment Management LLC, 2021. Forecast is compilation of forecasts for the 14 technologies that ARK defines as underlying the 5 innovation platforms. Assumes that traditional equity market exposures continue to compound value at a rate in excess of inflation and are not substantially disrupted or marked down by negative exposure to innovation. Cryptoassets are likely to be increasingly considered a different asset class by many; comparisons between cryptoasset values and equity market capitalization are cross-asset comparisons. Numbers rounded. Source: World Federation of Exchanges.

We Believe Disruptive Innovation Technologies Are Ready For Prime Time

2020: $14 Trillion



2030 Estimate: $210 Trillion



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Source: ARK Investment Management LLC, 2021

AI Innovation Could Increase Nearly 10-Fold To More Than $100 Trillion In Equity Market Capitalization By 2030

Mobile Connected Devices:

Humans could be enmeshing a constellation of connected devices that will inform us, entertain us, relate us, protect us, and mediate our perceptions of the world. Device constellations likely will be the dominant software development platforms, providing primary end-point distribution and productivity benefits. Legacy computation manufacturers and operating system providers could be in peril, along with media, entertainment, and content production companies with business models optimized for legacy distribution platforms.

Internet of Things:

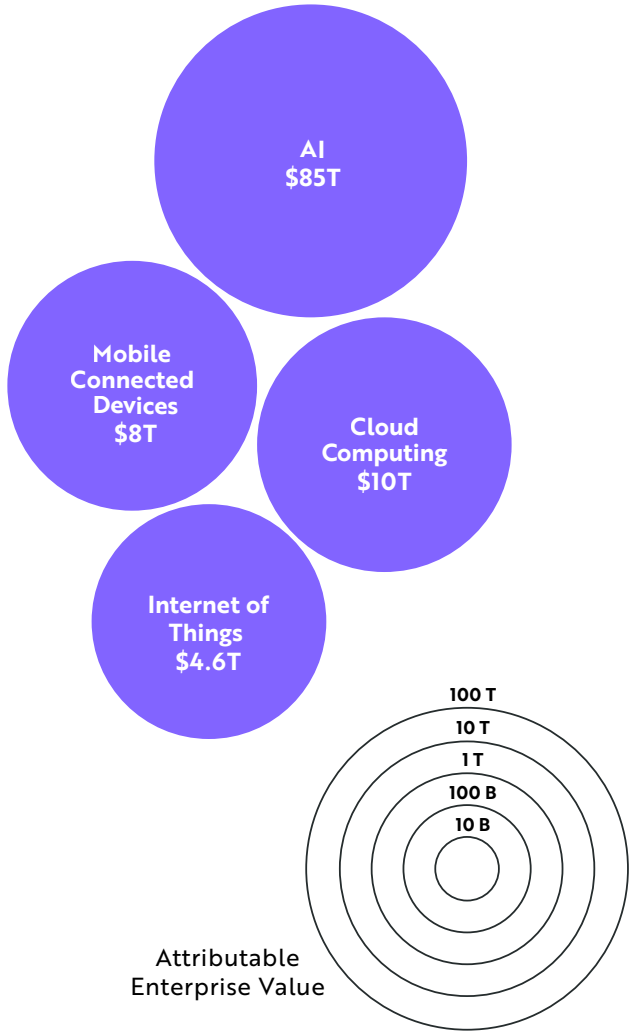
Internet of things could transform the distribution of media, providing end-users with new ways to interface with the world and capturing data-streams that enable the evolution of new business models and services. Consumer habits could be modified significantly and monetized in new ways. Voice interfaces should take share of e-commerce, digital mirrors should become fashion and exercise interfaces, and the age of linear TV could end. Digital distribution platforms are likely to accrue power as they promote private-label content and services.

AI:

Seemingly impossible problems could be solved by software and other computational systems that learn and change by integrating new data. These evolving systems should transform work and accelerate computational technology's integration into all economic sectors. The adoption of learning systems could prove more momentous than the introduction of the internet, transforming all economic sectors, including healthcare and financial services.

Cloud Computing:

Concentrated computational infrastructure could allow every device to harness the power of supercomputers, enabling continuous, data-driven improvements on the software side. Best-in-class solutions are likely to accrue winner-take-most share in each vertical, as customer lock-in drives superior economics. End user productivity should drive pricing, and should improve continuously based on data-informed solutions. Legacy software and hardware providers are likely to be vulnerable.



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Source: ARK Investment Management LLC, 2021

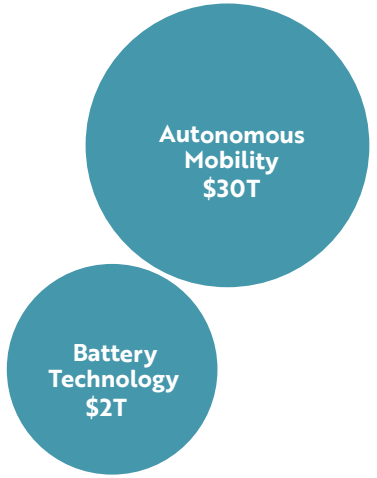
Battery Technology Could Enable Autonomous Mobility, Generating More Than $30 Trillion In Market Capitalization By 2030

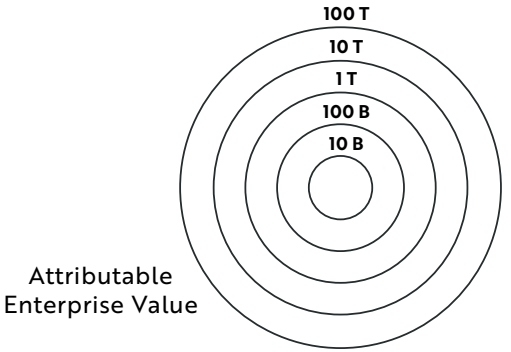
Battery Technology:

Declining battery costs could yield a Cambrian explosion in mobility form factors, pushing electrical supply out to network nodes and reducing EV prices enough to compete with traditional gas-powered cars. Micro-mobility and aerial systems, including flying taxis, could transform landscapes and accelerate demand for electric energy displacing liquid fuel. Traditional automotive manufacturers and their suppliers could topple; oil demand globally is in the process of peaking and infrastructure will likely have to adapt.

Autonomous Mobility:

Battery-powered robots moving people and parcels could operate atop legacy transportation infrastructure, transforming the economics of physical movement by an order of magnitude. Taxi service could become the norm and ownership of personal vehicles the exception; frictionless delivery could turbocharge ecommerce; and autonomous mobility-driven data should provide real-time insights into the state of the world. Incumbent providers in the automotive, logistics, retail, and insurance sectors could be upended.





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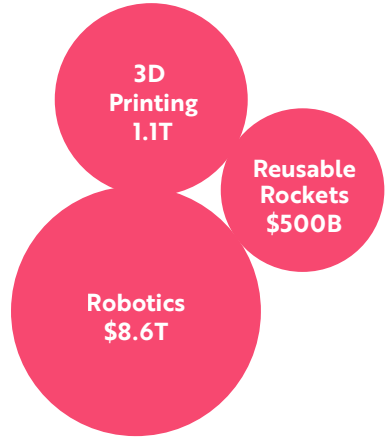
Robotics Advances Could Generate More Than $10 Trillion In Equity Capitalization By 2030

3D Printing:

3D printing could transform traditional manufacturing methods by removing design barriers and reducing cost, weight, and time to production. Already healthcare tools created with 3D printing can be personalized, enhancing experiences for both patients and doctors. Light 3D printed aerospace parts could reduce global emissions and give flight to new aircraft for earth and outer space. 3D printing with artificial intelligence could design-on-demand innovative parts better suited to their end applications at a fraction of traditional manufacturing costs.

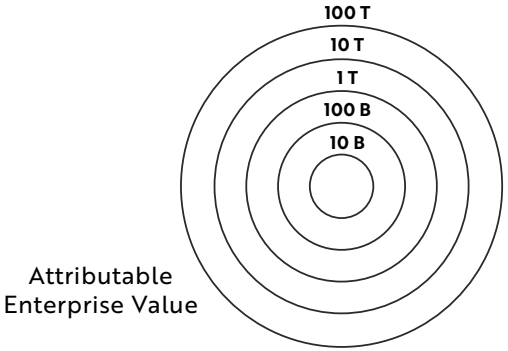
Reusable Rockets:

Once a ludicrous notion, nearly every launch provider today appears to be making plans for rocket reuse, which should lower costs by an order of magnitude and enable exciting new business models. Given the economics of rocket reuse, both low earth orbit constellations and hypersonic point-to-point travel could become feasible, transforming military asset delivery, shrinking the world's supply chains, and enabling economical broadband connectivity anywhere on Earth.



Robotics:

Collaborative robots powered by artificial intelligence could flourish in increasingly dynamic environments, transforming the economy. Harnessing the power of AI, robots likely will learn from and adapt to the world around them, lowering upfront and training costs. More companies are likely to participate, supercharging productivity across industries.



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Source: ARK Investment Management LLC, 2021.

Genomic Technologies Could Drive More Than $3 Trillion In Equity Market Capitalization By 2030

Gene Sequencing:

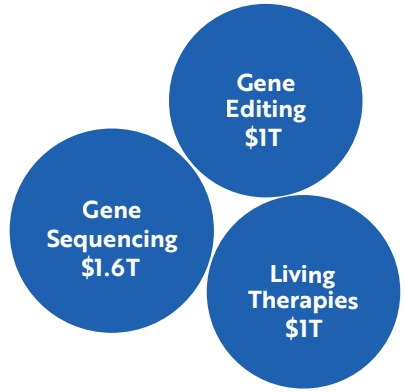
As genome sequencing costs fall, tests once limited to research labs should be deployed widely, spurring volume increases by three orders of magnitude. Pan-cancer blood tests are likely to scale and commercialize, therapeutic treatments should become more precise and efficacious, and highly effective measures against inherited complex disorders should become prophylactic. Importantly, gene sequencing advances could extend into agriculture and materials science. Legacy drug franchises and traditional diagnostic testing businesses likely will be vulnerable.

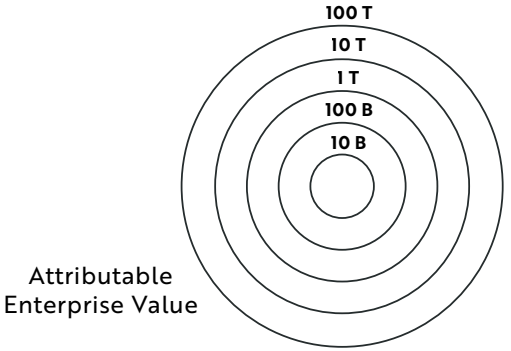
Living Therapies:

Genetic tools that create new forms of therapeutic intervention could emerge, enabling precise, efficacious, and durable treatments against pernicious and chronic diseases. The promise of curing disease could boost investment in tooling and delivery infrastructure that is likely to command and sustain premium prices while improving health outcomes. Advances in this field also could set the stage for cultivated protein products that transform the economics of food production. Companies with early-stage cancer franchises could be at risk.

Gene Editing:

Editing technology can insert or delete genes in a targeted portion of the human genome. Catalyzed by the 2012 discovery of CRISPR, these molecular editors are effective, inexpensive, and accessible technologies that could advance our ability to understand and manipulate biological systems. In health settings they allow for faster and more precise pre-clinical experimentation, improving the probability of early-stage research entering clinical trials. At the therapeutic level they enable the repair of genetic disorders and curative treatments for rare diseases. This revolutionary gene technology, alongside emerging genetic synthesis techniques, could expand further into agriculture, food production, pest control, materials, and energy.





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Source: ARK Investment Management LLC, 2021.

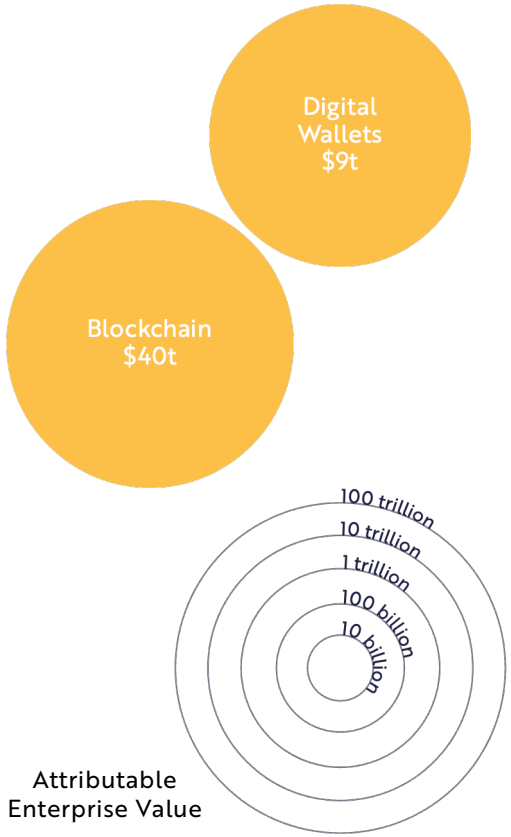
ARK Expects Cryptoassets And Digital Wallets To Command Nearly $50 Trillion In Equity Market Capitalization By 2030

Blockchain:

All money and contracts could migrate to open-source protocols that enable and verify digital scarcity and proof-of-ownership. The financial ecosystem could be forced to reconfigure to take advantage of the capabilities these technologies afford, potentially leading to more transparency, fewer capital and regulatory controls, and significantly lower contract execution costs. More of everything could become money-like: fungible, liquid, quantifiable; every corporate entity and consumer will have to adapt; corporate structures might be called into question; every sector could be impacted.

Digital Wallets:

Digital wallets allow anyone with a connected device to transact money instantly, transforming commercial and financial experiences. Consumers hold the power of a bank branch in their pockets and demand wholesale pricing for many financial transactions, changing their relationships with financial service providers. We believe that trillions in annual cash transactions will be digitized, presenting a data monetization opportunity roughly equivalent to that of Google Search. Digital wallets could become the point-of-contact for a variety of digital services. Traditional financial services institutions could be at risk.



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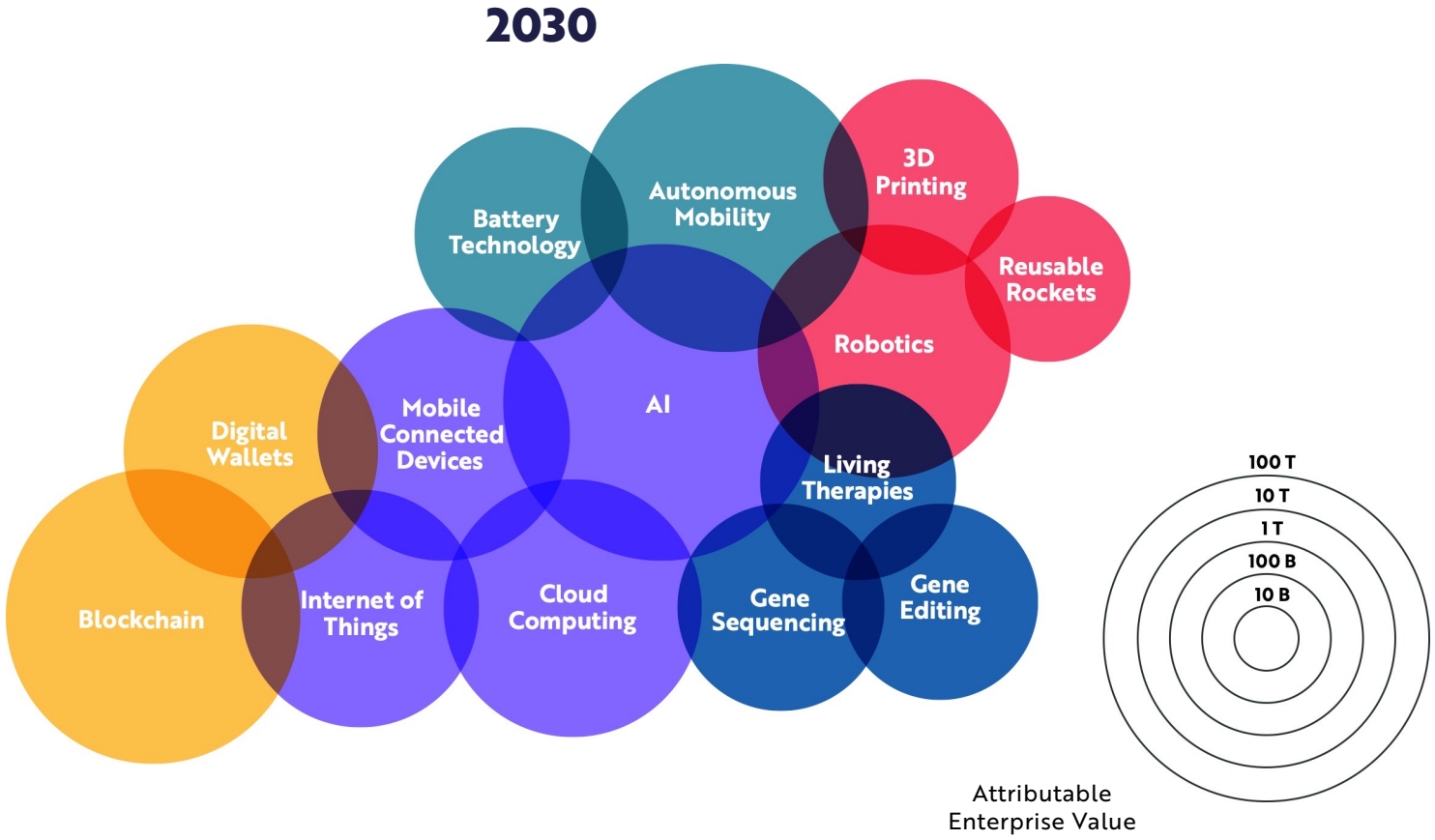
Source: ARK Investment Management LLC, 2021.

Convergence Across Technologies Could Amplify Their Potential

Converging technologies:

- The convergence of robotics, battery technologies, and artificial intelligence is likely to collapse the cost structure of transportation, impacting the economics of auto, rail, and airline activities.
- The convergence of next generation DNA sequencing, artificial intelligence, and gene therapies should boost returns on investment significantly, potentially creating a golden age of health care likely to rival that of the eighties and nineties.
- The convergence of application programming interfaces (APIs), social platforms, and blockchain technology could integrate business and consumer marketplaces, disintermediating the middlemen dominating financial ecosystems.



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Source: ARK Investment Management LLC, 2021.

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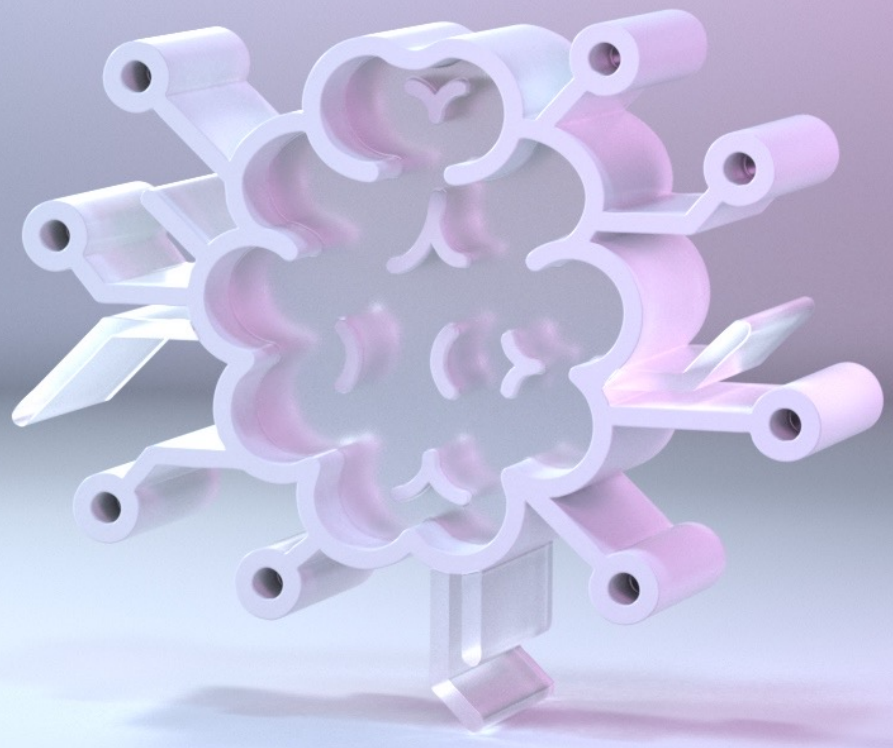
Artificial Intelligence

Enabling Humans To Become Superhuman

Research by William Summerlin and Frank Downing, ARK Analysts



Artificial Intelligence (AI) training costs appear to be declining at more than twice the rate of Moore's Law[1] as performance is increasing significantly.

By automating the tasks of knowledge workers, AI should boost productivity and lower unit labor costs significantly. Our research suggests that the market capitalization of AI hardware and software companies could scale at roughly 50% annualized rate, increasing from $2.5 trillion in 2021 to $87 trillion by 2030.

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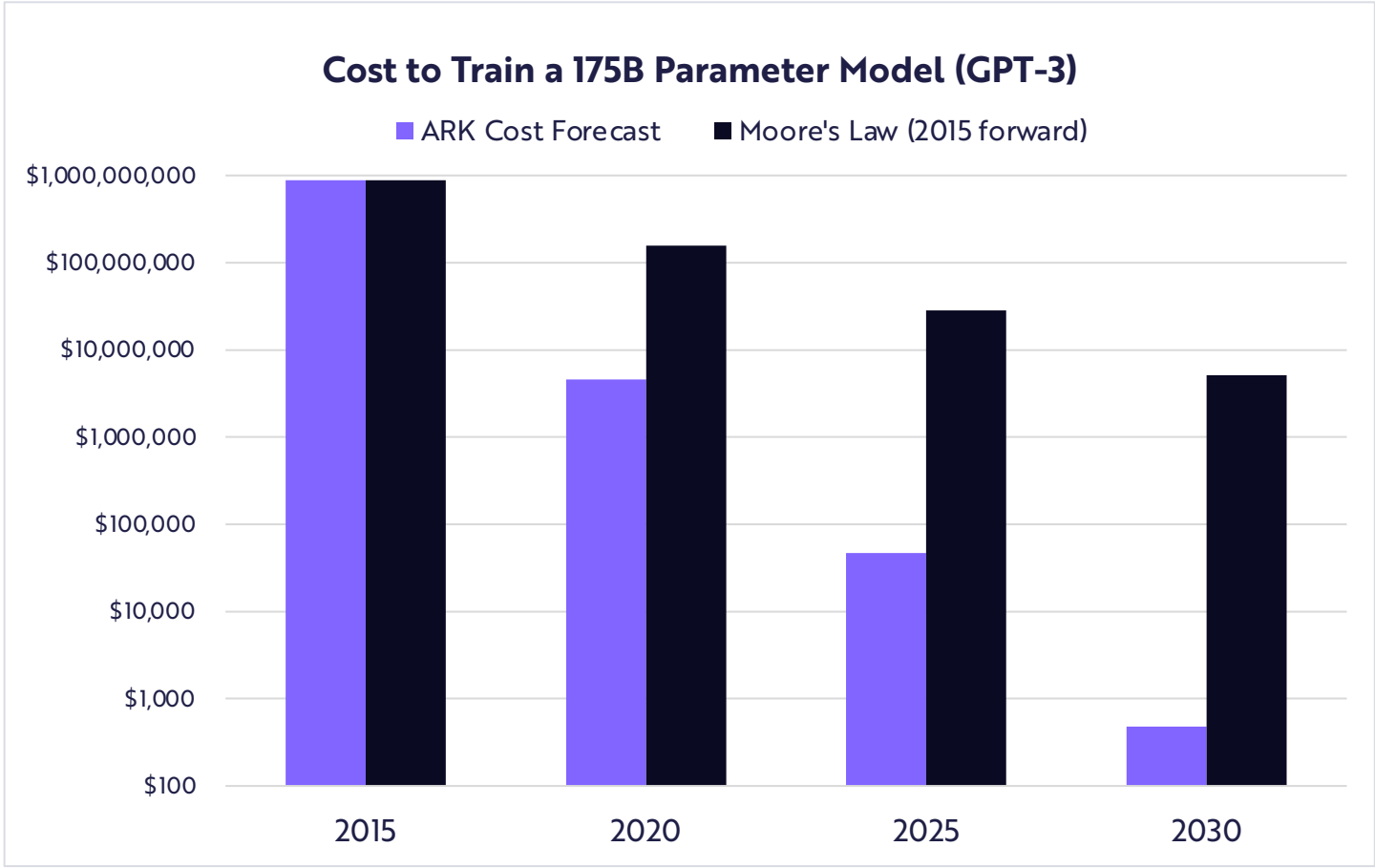
[1] Moore's Law suggests that the number of transistors per silicon chip doubles every two years, thereby reducing the cost of compute by 50%.
Source: ARK Investment Management LLC, 2021.

AI Training Costs Appear To Be Declining At Twice The Rate Of Moore's Law

GPT-3 is a large language model that uses deep learning to generate text, ranging from translation to poetry composition.

From 2015 to 2020, the cost to train a GPT-3 sized model dropped 65% at an annual rate, from $875 million to $4.6 million. According to our research, the cost will decline another four orders of magnitude to $500 in 2030.

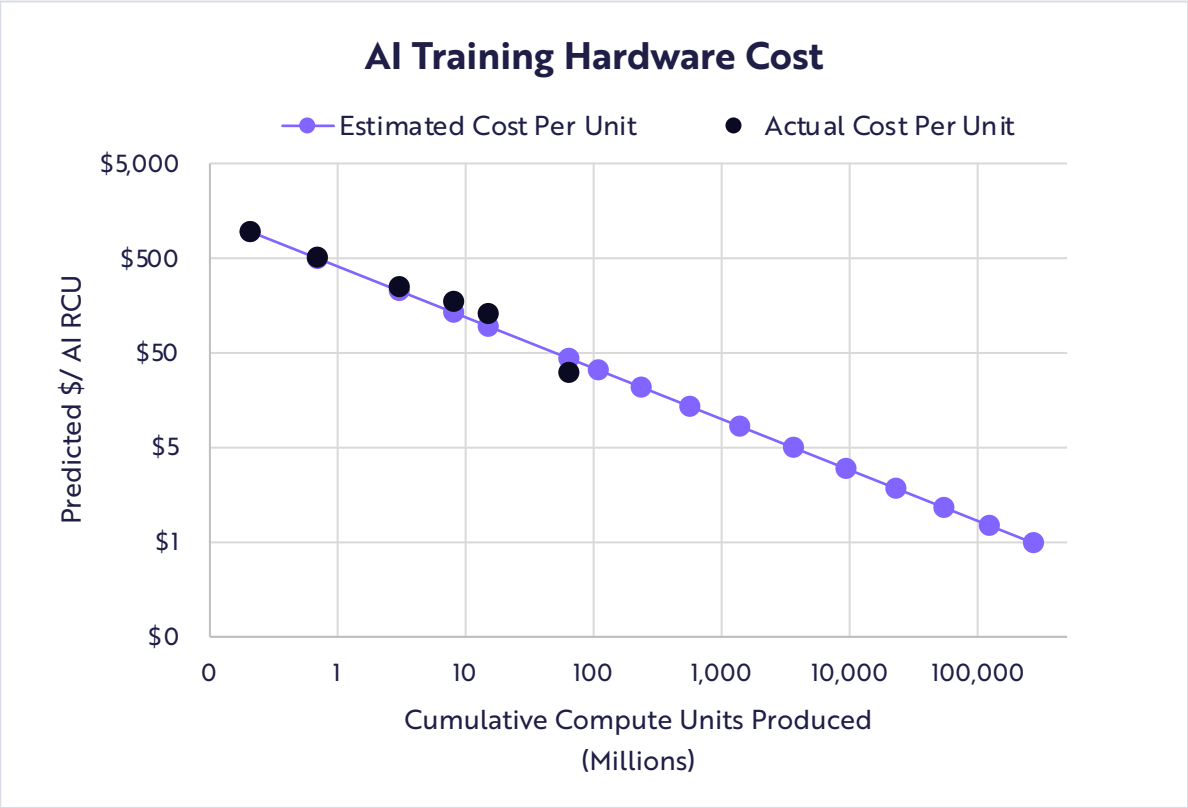
Given 240 trillion synapses, the cost to train a neural network equivalent in size to the human brain in 2021 would have been $2.5 billion and is likely to drop 60% at an annual rate to $600,000 by 2030.

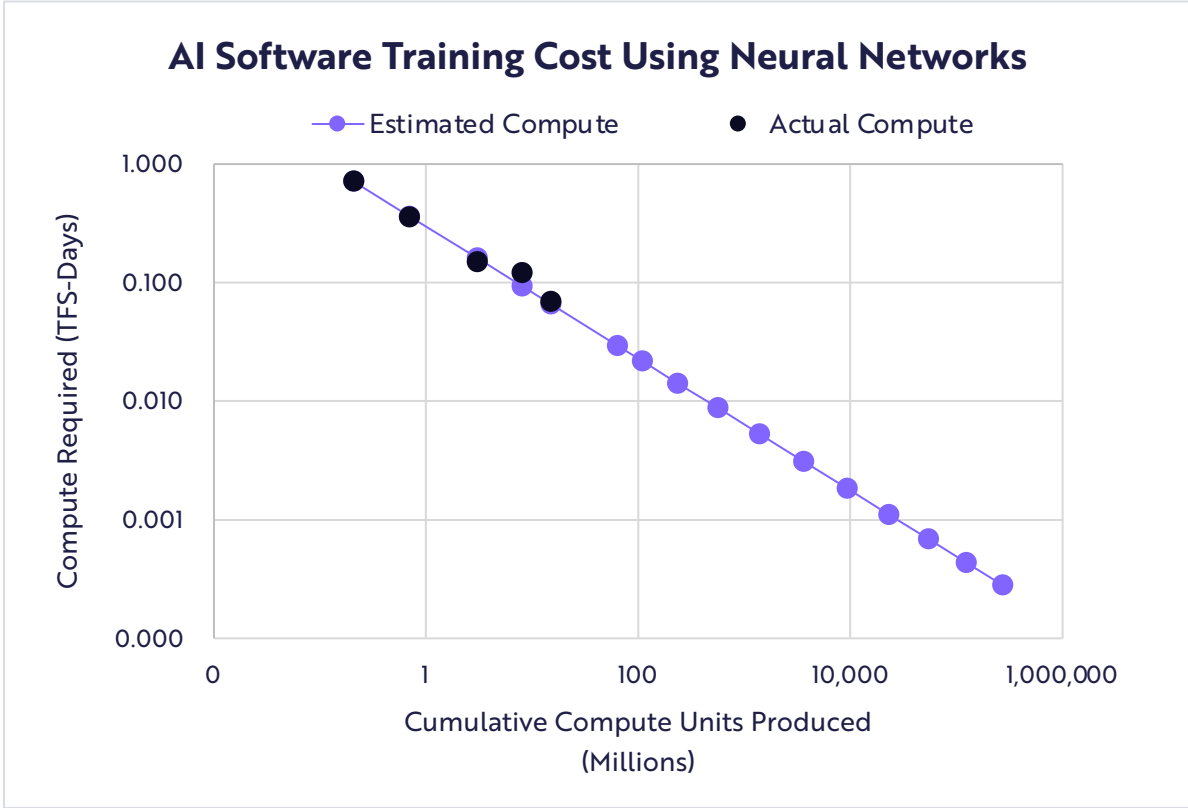


 Source: ARK Investment Management LLC, 2021 based on data sourced from Hernandez, Danny, and Tom Brown. "AI and Efficiency." OpenAI, OpenAI, May 2020, openai.com/blog/ai-and-efficiency/, NVIDIA., "Demystifying GPT-3." lambdalabs.com/blog/demystifying-gpt-3/., and"Brain Facts and Figures." faculty.washington.edu/chudler/facts.html.

Wright's Law Models The Cost Declines Of AI Hardware And Software

Informed by Wright's Law, we estimate that AI-relative compute unit (RCU) production costs could decline at a 39% annual rate and that software improvements could contribute an additional 37% in cost declines during the next eight years. In other words, the convergence of hardware and software could drive down AI training costs by 60% at an annual rate by 2030.





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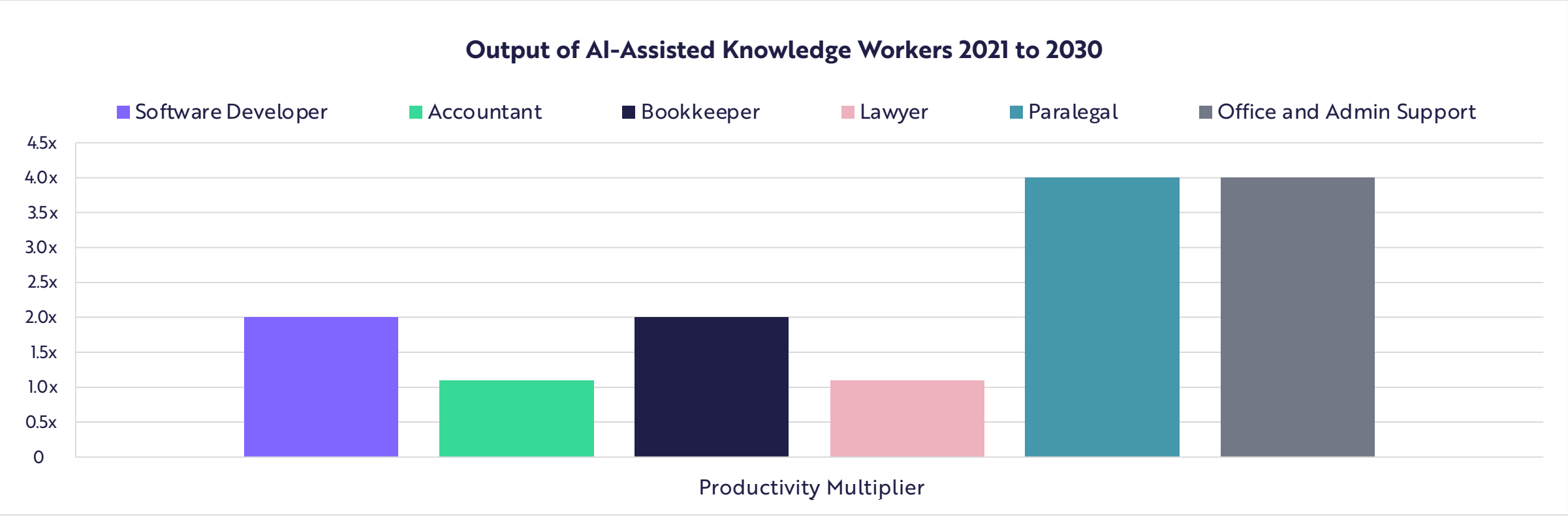
Source: ARK Investment Management LLC, 2021 based on publicly available data sourced from Hernandez, Danny, and Tom Brown. "AI and Efficiency." OpenAI, OpenAI, May 2020, openai.com/blog/ai-and-efficiency/, and NVIDIA. TFS-Days is a measure of compute required to train a model. AI-Relative Compute Unit (RCU) is a measure of relative performance improvement on AI training compared against a NVIDIA K80 (2014) baseline.

AI Could Automate The Tasks Of Knowledge Workers And Boost Productivity

Our research suggests that by 2030 AI will increase the output of knowledge workers by 140%.



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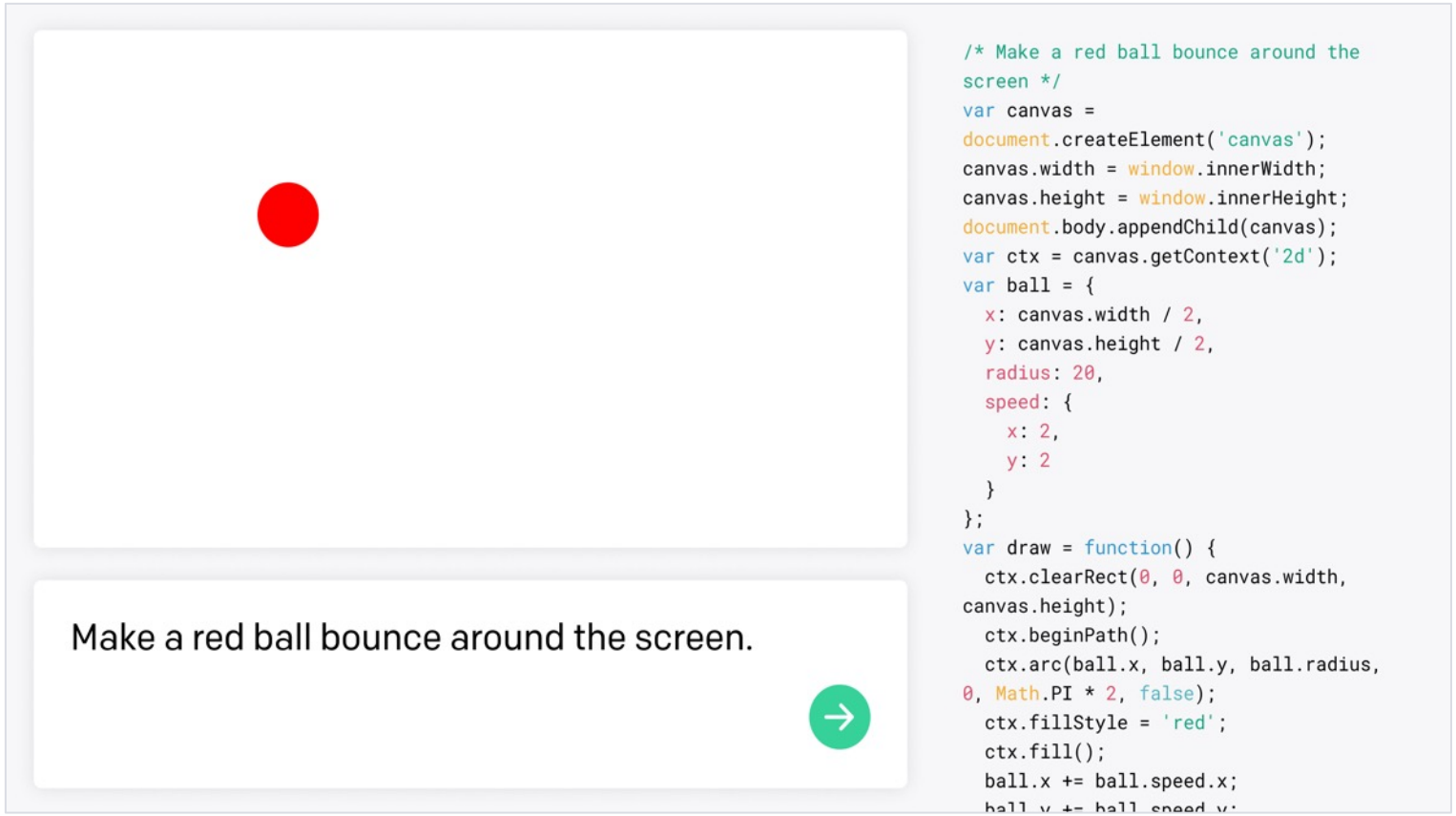
Example:
OpenAI Codex Already Can Complete 37% Of Coding Tasks

Codex can translate English language commands like “Make a red ball bounce around the screen” into software code, potentially saving software developers hours of time.

Today, Codex can complete 37% of coding tasks, a percentage that is likely to increase significantly during the next few years.



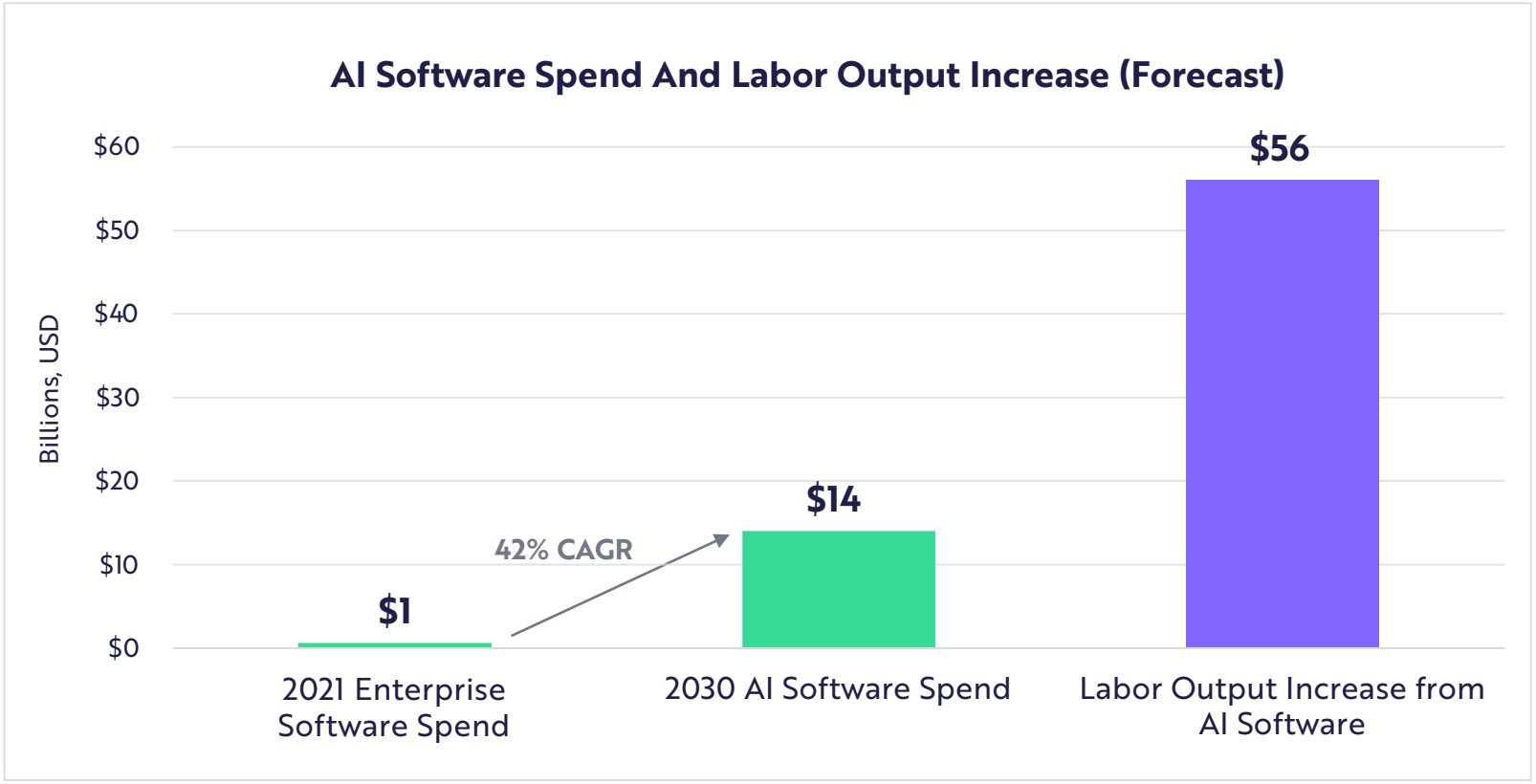
Source: “OpenAI Codex.” openai.com/blog/openai-codex.

AI Could Accelerate Productivity Gains

By 2030, artificial intelligence is likely to boost the output of global knowledge workers by 9% at an annual rate, from $41 trillion in expected human labor output to roughly $97 trillion in AI + human output.

ARK estimates that organizations will increase spending on enterprise software by 42% at an annual rate to $14 trillion a year.

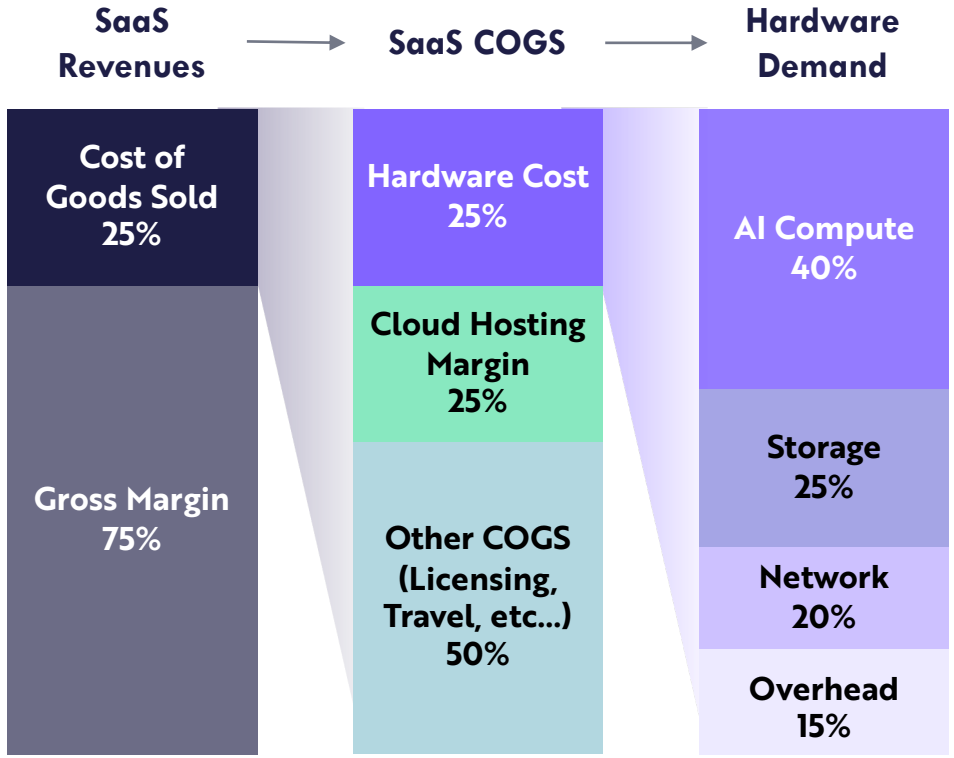
If automation boosts productivity by 140%, AI software could increase the output of global knowledge workers at an annual rate of 9% to $97 trillion in 2030.

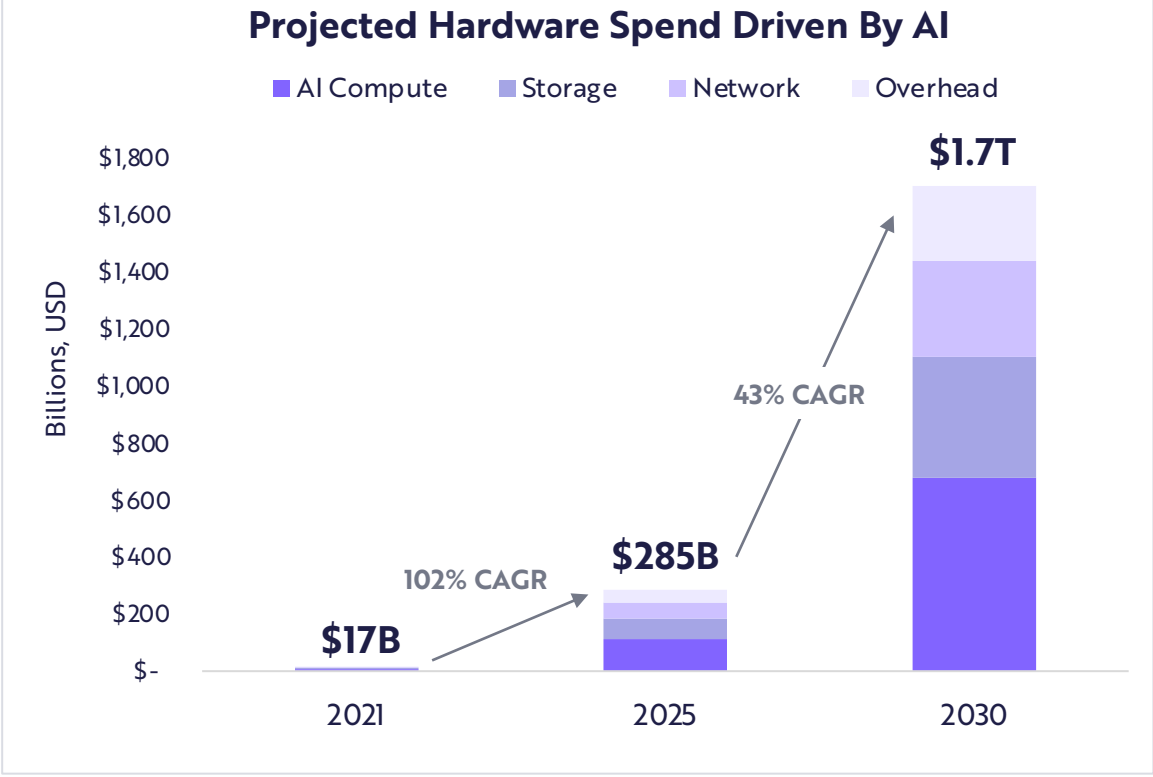


Forecasts are inherently limited and cannot be relied upon. | For informational purposes only and should not be considered investment advice, or a recommendation to buy, sell or hold any particular security. Forecast excludes China. Source: ARK Investment Management LLC, 2021 analysis based on company derived statistics and data sourced from the US Bureau of Labor Statistics. "Occupational Employment and Wage Statistics." www.bls.gov/oes/current/oes_stru.htm., Gartner gartner.com/en/newsroom/press-releases/2021-10-20-gartner-forecasts-worldwide-it-spending-to-exceed-4-trillion-in-2022, and McKinsey Global Institute. "A Future That Works: Automation, Employment, and Productivity." mckinsey.com/~/media/mckinsey/featured%20insights/digital%20disruption/harnessing%20automation%20for%20a%20future%20that%20works/mgi-a-future-that-works_full-report.pdf

AI Software Should Boost Demand For AI Hardware

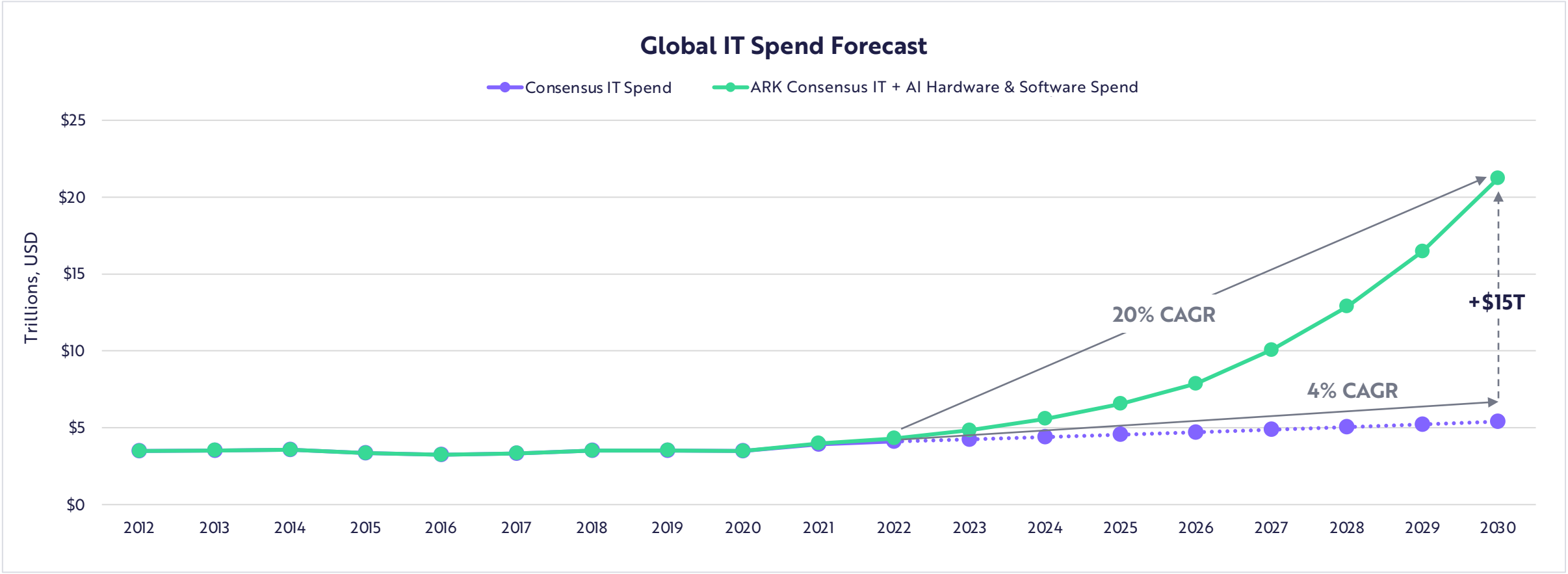
ARK estimates that SaaS companies spend 50%+ of their cost of goods sold (COGS) on infrastructure hosting costs. As demand for AI software grows, the demand for hardware could rise accordingly.





Forecasts are inherently limited and cannot be relied upon. | For informational purposes only and should not be considered investment advice, or a recommendation to buy, sell or hold any particular security. Source: ARK Investment Management LLC, 2021 based on data sourced from a16z. "The Cost of Cloud..." https://a16z.com/2021/05/27/cost-of-cloud-paradox-market-cap-cloud-lifecycle-scale-growth-repatriation-optimization/, Gartner gartner.com/en/newsroom/press-releases/2021-10-20-gartner-forecasts-worldwide-it-spending-to-exceed-4-trillion-in-2022., and IDC. https://www.idc.com/getdoc.jsp?containerId=prUS47961621. https://www.idc.com/getdoc.jsp?containerId=prUS47528921. https://www.idc.com/getdoc.jsp?containerId=prUS47525621. https://www.idc.com/getdoc.jsp?containerId=prUS47525621.

Spending On Global AI Software And Hardware Could Be More Than Triple The Consensus Expectation By 2030



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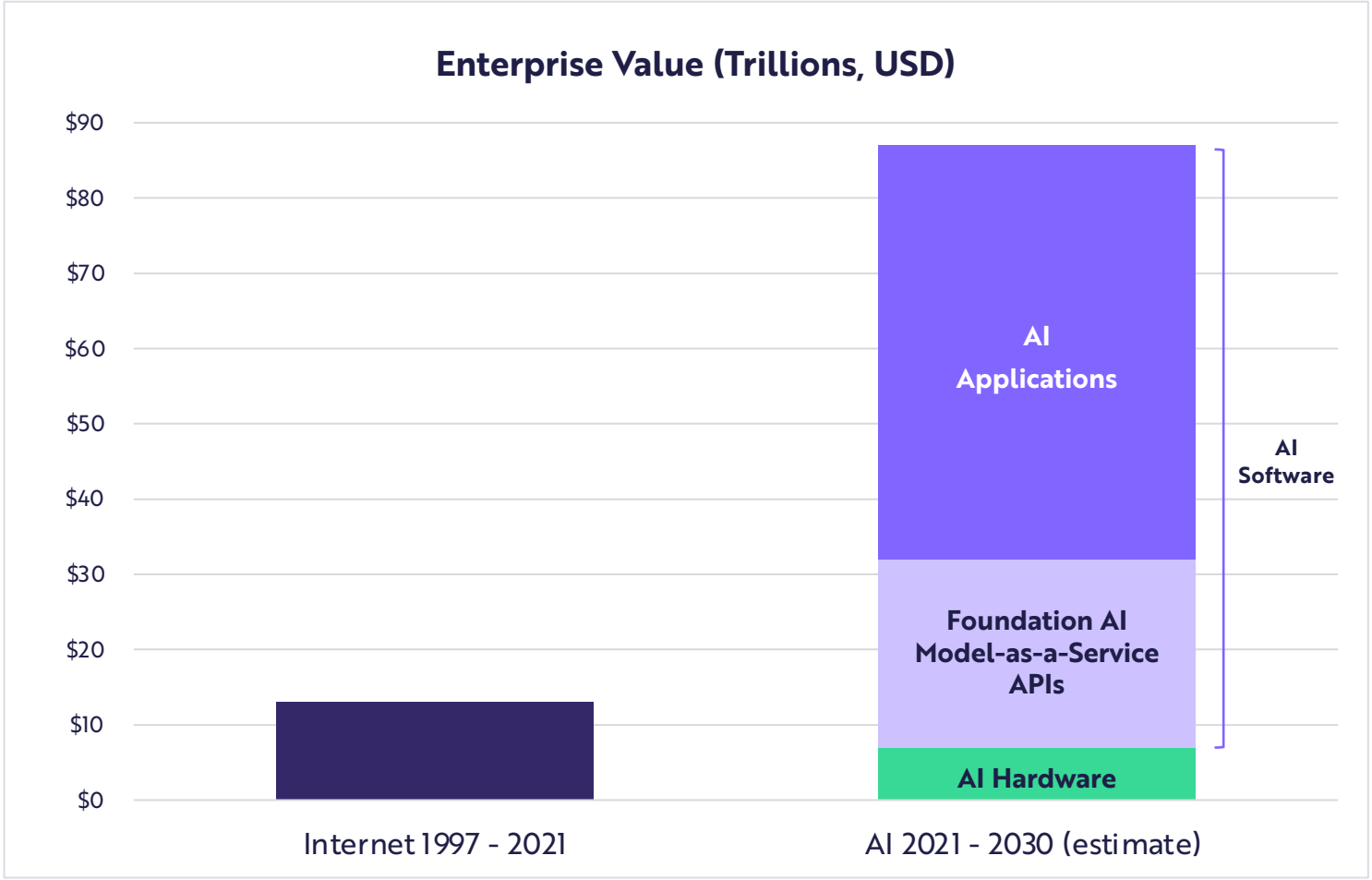
Source: ARK Investment Management LLC, 2021 based on data from company derived statistics and Gartner gartner.com/en/newsroom/press-releases/2021-10-20-gartner-forecasts-worldwide-it-spending-to-exceed-4-trillion-in-2022

Artificial Intelligence Could Scale From Almost $2.5 Trillion To $87 Trillion In Enterprise Value By 2030

By 2030, AI software companies could produce $14 trillion in annual revenue collectively. The resulting $4 trillion in free cash flow could create over $80 trillion in enterprise value, up from $2.3 trillion in 2021, generating returns of 48% at a compound annual annual rate during the next nine years.

By 2030, AI hardware companies could produce $1.7 trillion in annual revenue collectively. The resulting $350 billion in free cash flow could create $7 trillion in enterprise value, generating returns of 57% at a compound annual annual rate during the next nine years.



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Source: ARK Investment Management LLC, 2021

ARK INVEST

Digital Consumers

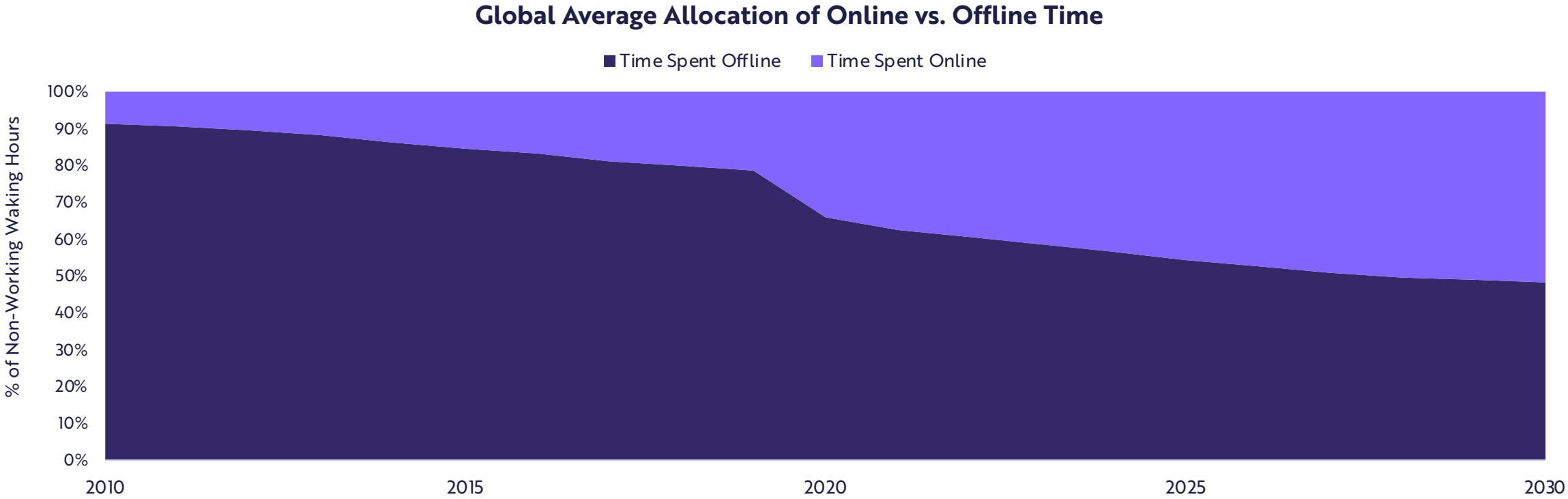
Spending More Time and Money Online

Research by Nicholas Grous, ARK Analyst, and Andrew Kim, ARK Analyst Intern

The new digitally native consumer is spending an increasing amount of time socializing, playing, and purchasing online. As digital takes share in our daily lives, we believe the market—as measured by online entertainment spend, advertising spend, and platform e-commerce fees—is likely to grow at an 18% compound annual rate during the next five years, from $1.8 trillion today to $4.1 trillion in 2026.

Digital Is Taking Share Of Our Lives

The COVID-19 crisis accelerated the shift from offline to online activities. We estimate that on average in 2021, internet users spent 38% of their free time online and 62% offline. By 2030, we expect these averages to flip, with users spending 52% of their free time online and 48% offline.



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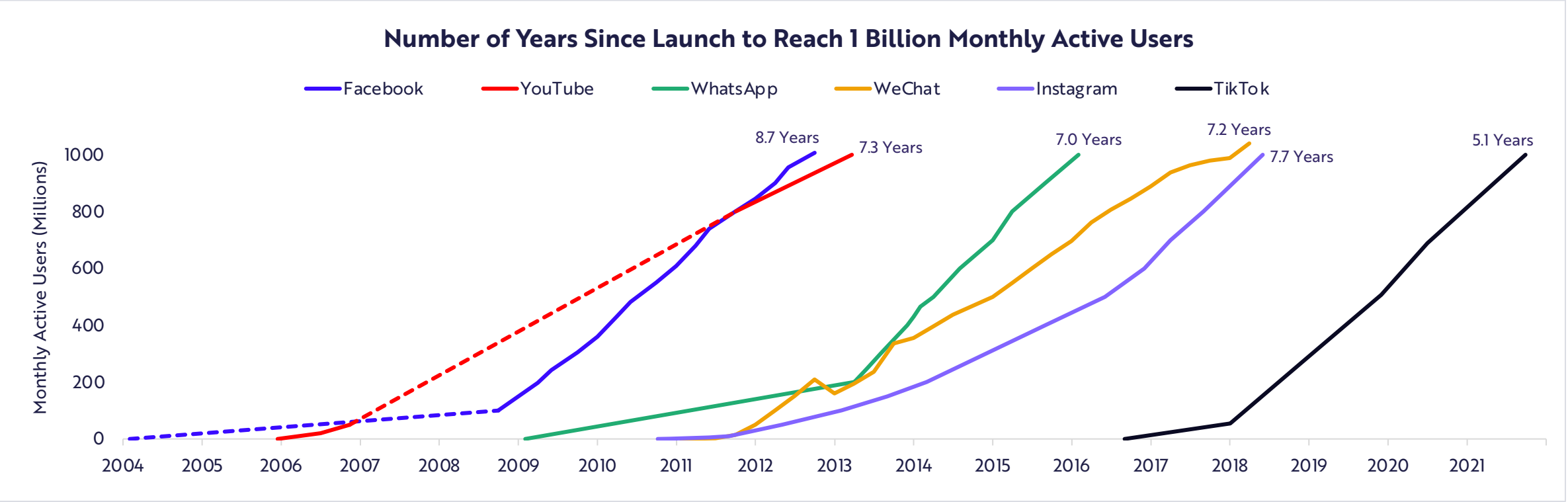
Source: ARK Investment Management LLC, 2021, data sourced from eMarketer, Federal Reserve Economic Data, Organization for Economic Cooperation and Development, United States Census Bureau, United States Department of Labor, and World Bank Group.

Social Platforms Are Scaling Like Never Before

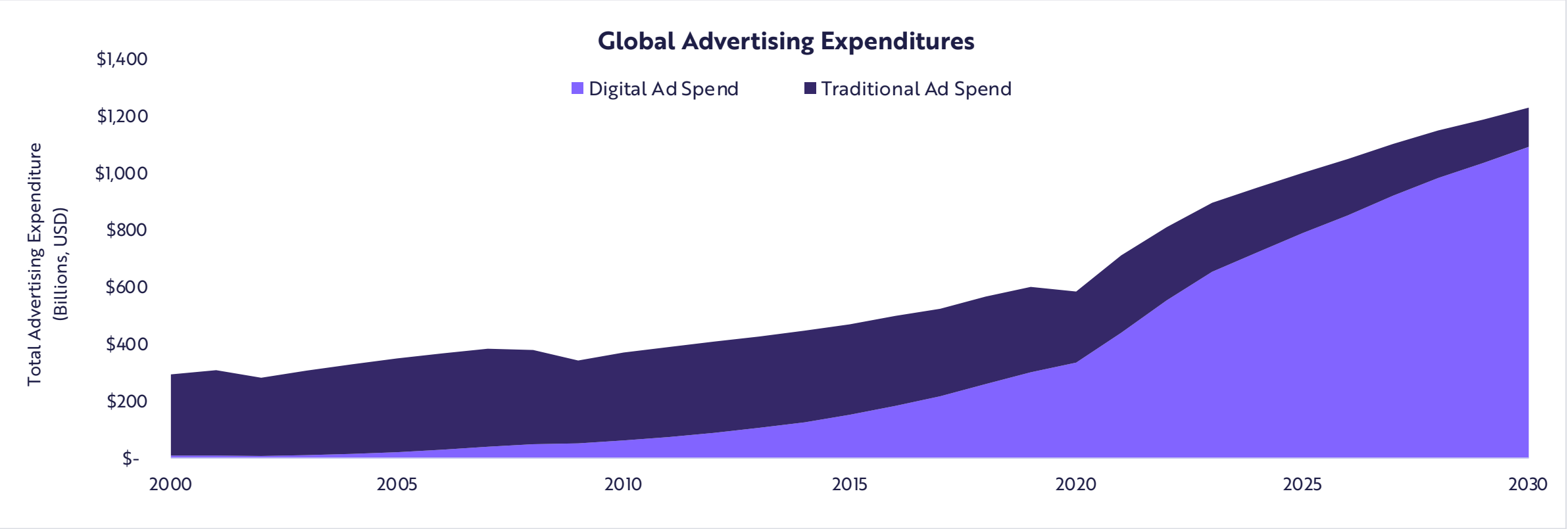
The accelerating adoption of online platforms gives businesses and individuals the ability to reach global audiences.
Today, six platforms have more than 1 billion monthly active users, and 29 platforms have at least 100 million monthly active users.



For informational purposes only and should not be considered investment advice, or a recommendation to buy, sell or hold any particular security.
Source: ARK Investment Management LLC, 2021, "List of social platforms with at least 100 million active users," Wikipedia, last accessed January 18, 2022, https://en.wikipedia.org/wiki/List_of_social_platforms_with_at_least_100_million_active_users, data sourced from CNBC, Meta Platforms, TechCrunch, Tencent Holdings, and USA Today.

Digital Advertising Is The Primary Channel For Reaching Consumers

As traditional advertising declined during the Covid-19 pandemic, digital advertising gained share. By the end of 2021, global digital advertising totaled roughly $440 billion, or 62% of the total advertising market. We believe the global digital advertising market will grow at a 11% compound annual rate over the next eight years, surpassing $1 trillion in expenditures by the end of 2029.



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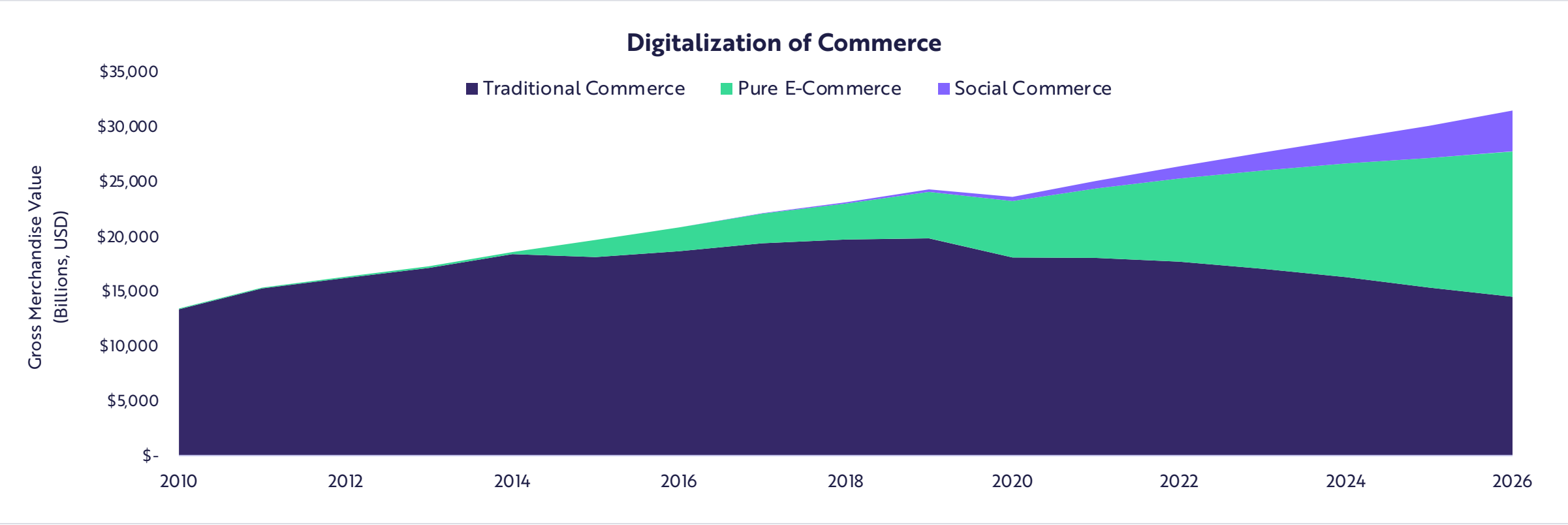
Source: ARK Investment Management LLC, 2021, data sourced from Kagan Research and MAGNA Global USA.

Social Commerce Is The Next Wave In Online Shopping

When implemented correctly, social commerce combines the convenience of online shopping with the network effects of social media. We expect social commerce gross merchandise value (GMV) to grow at a compound annual rate of 41% over the next five years to $3.7 trillion, more than doubling it from less than 10% of total e-commerce today to 22% in 2026.



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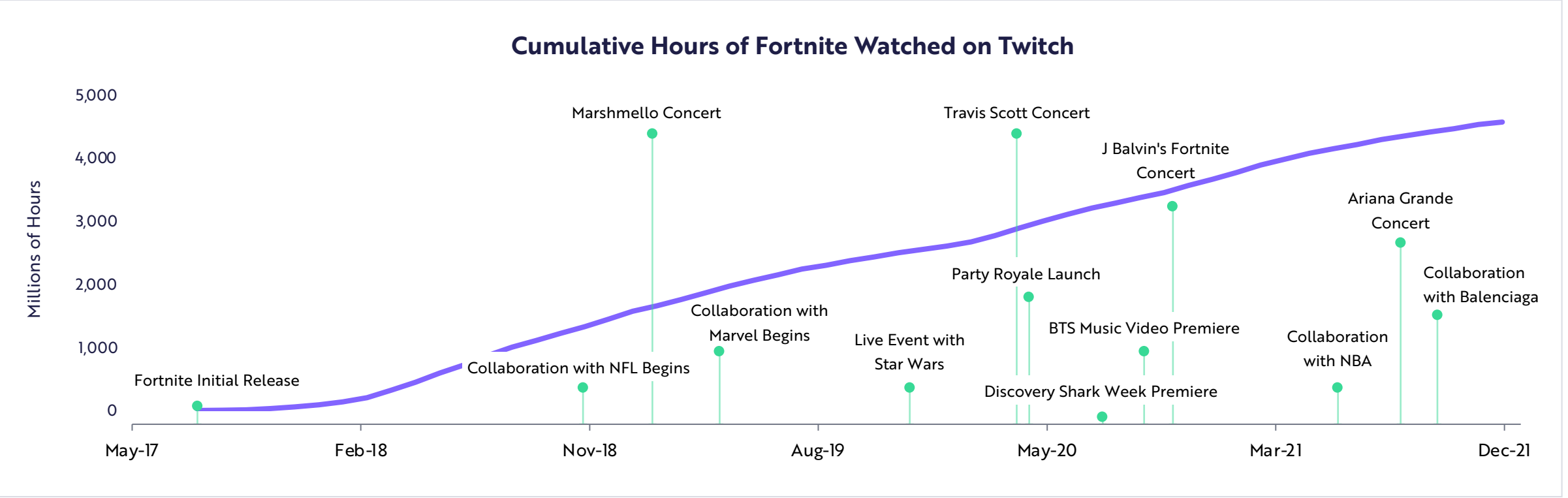
Note: We define social commerce as any online sale of a physical good that takes place within a social media platform or via e-commerce platforms through social features.
Source: ARK Investment Management LLC 2021, data from Bond Capital, CEIC Holdings, China Internet Watch, Digital Commerce 360, eMarketer, EuroCommerce, FTI Consulting, Invesp, National Bureau of Statistics of China, and U.S. Census Bureau.

Games Are The New Social Platforms

Fortnite exemplifies the massive shift to social gaming. Launched in 2017 as a first-person battle royale game, today Fortnite holds virtual concerts for millions of players and has dedicated spaces in which users can hang out. We estimate that video game content and services will grow at a 15% compound annual growth rate from roughly $200 billion in 2021 to more than $400 billion by 2026 with the rise of "virtual worlds."



Forecasts are inherently limited and cannot be relied upon. | For informational purposes only and should not be considered investment advice, or a recommendation to buy, sell or hold any particular security.
Our estimate and forecast for the video game industry include only video game content and services and exclude related hardware and accessory sales.
Source: ARK Investment Management LLC, 2021, data sourced from Epic Games, NPD Group, and TwitchTracker.

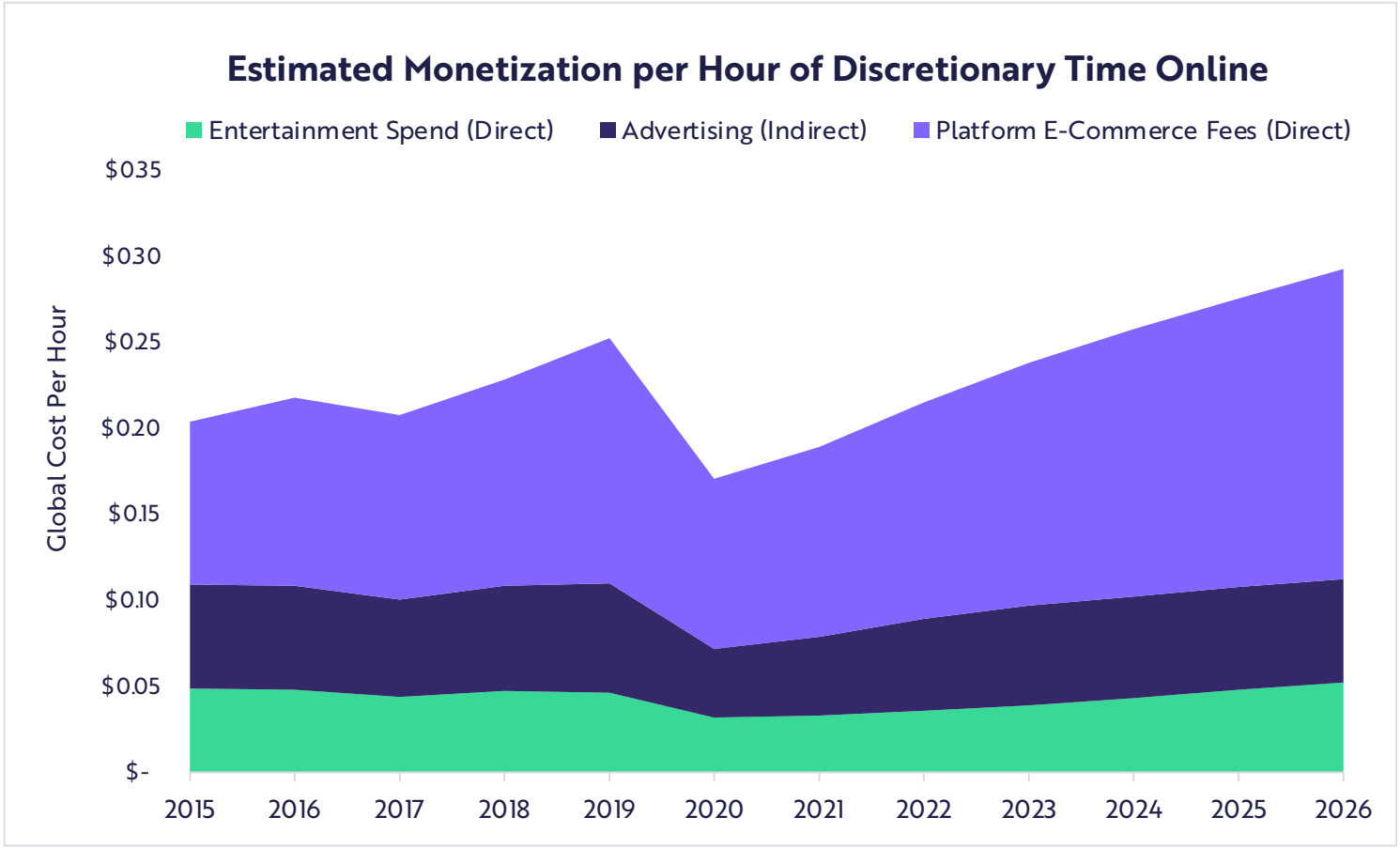
We Estimate That The Revenue Associated With Discretionary Online Time Will Increase From $1.8 Trillion Today To $4.1 Trillion In 2026

We identify three online revenue segments:

- Entertainment Spend
- Advertising
- Platform E-Commerce Fees

Based on ARK's research, the market should grow from $0.19 to $0.29 on a cost per hour basis during the next five years.

On a total revenue basis, we expect the market to grow at a 18% compound annual rate during the next five years, from $1.8 trillion today to $4.1 trillion in 2026.



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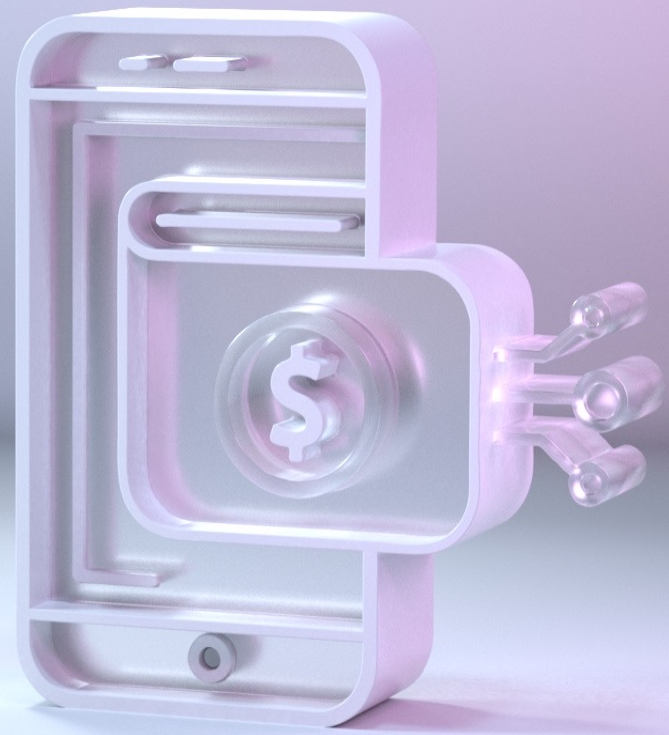
Source: ARK Investment Management LLC, 2021, data sourced from CEIC Data, China Internet Watch, Department of Labor and Training, Digital Commerce 360, EuroCommerce, eMarketer, Federal Reserve Economic Data, FTI Consulting, Invesp, Mary Meeker, National Bureau of Statistics of China, Newzoo, NPD Group, Organization for Economic Cooperation and Development, Statista, US Census Bureau, the World Bank, and US Bureau of Labor Services..

ARK INVEST

Digital Wallets

Upending Traditional Banking

Research by Max Friedrich, ARK Analyst, and Nishita Jain, ARK Research Associate



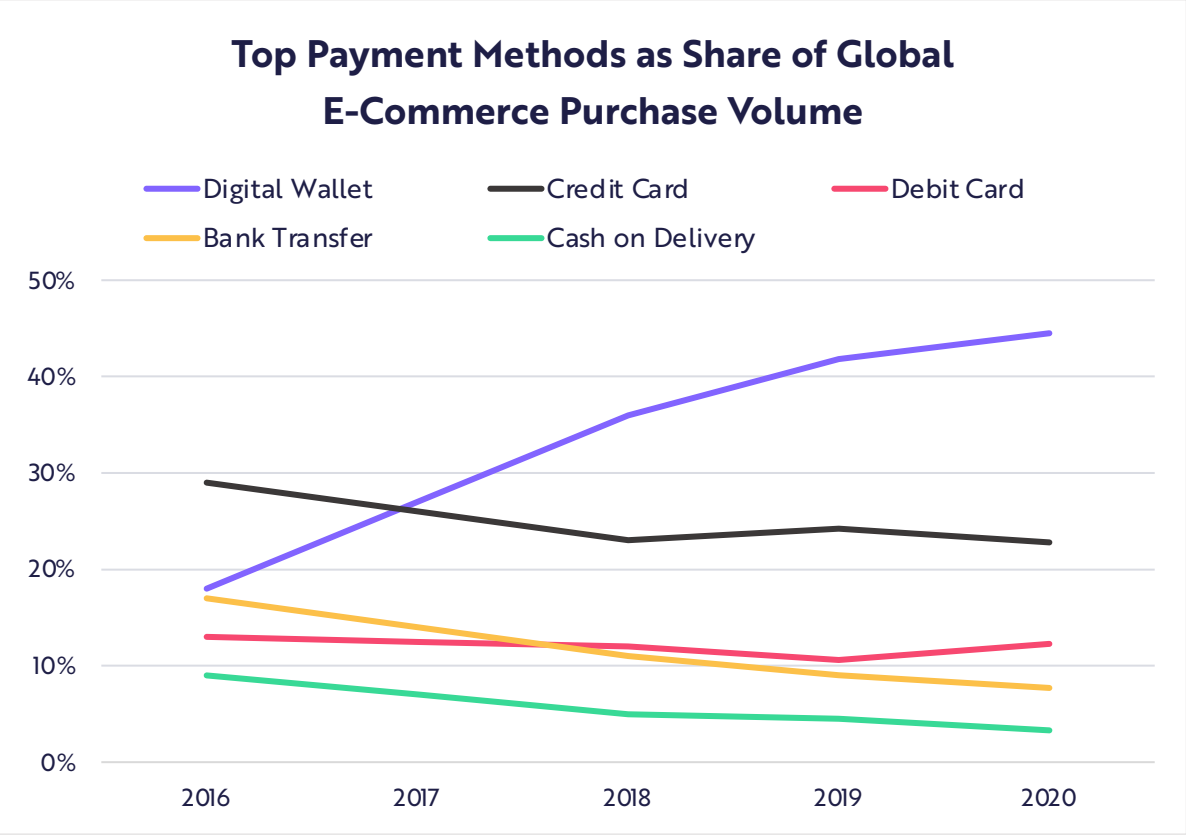
Today, digital wallets like Venmo, Cash App, and others around the globe are penetrating traditional financial services, including brokerage and lending, thanks to what we believe are superior user experiences and much lower costs of acquisition.

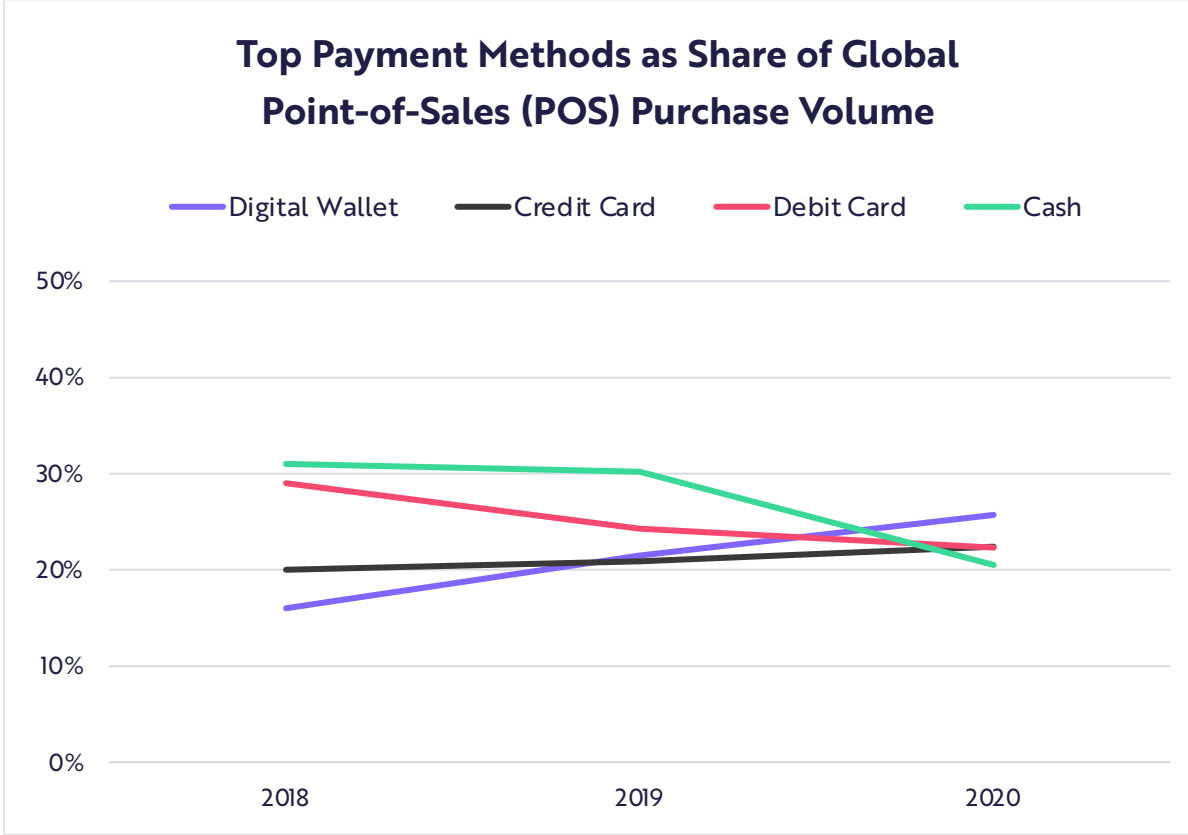
In ARK's view, digital wallets could scale at an annual rate of 69% in the US, from more than $400 billion in market capitalization to $5.7 trillion, and 78% globally, from $1.1 to $20 trillion, during the next five years.

Source: ARK Investment Management LLC, 2021

Digital Wallets Are The Number One Payment Method Offline And Online

Dominating e-commerce payments since 2017, digital wallets surpassed cash last year in point-of-sales (POS) payments, likely in response to the COVID-19 pandemic.

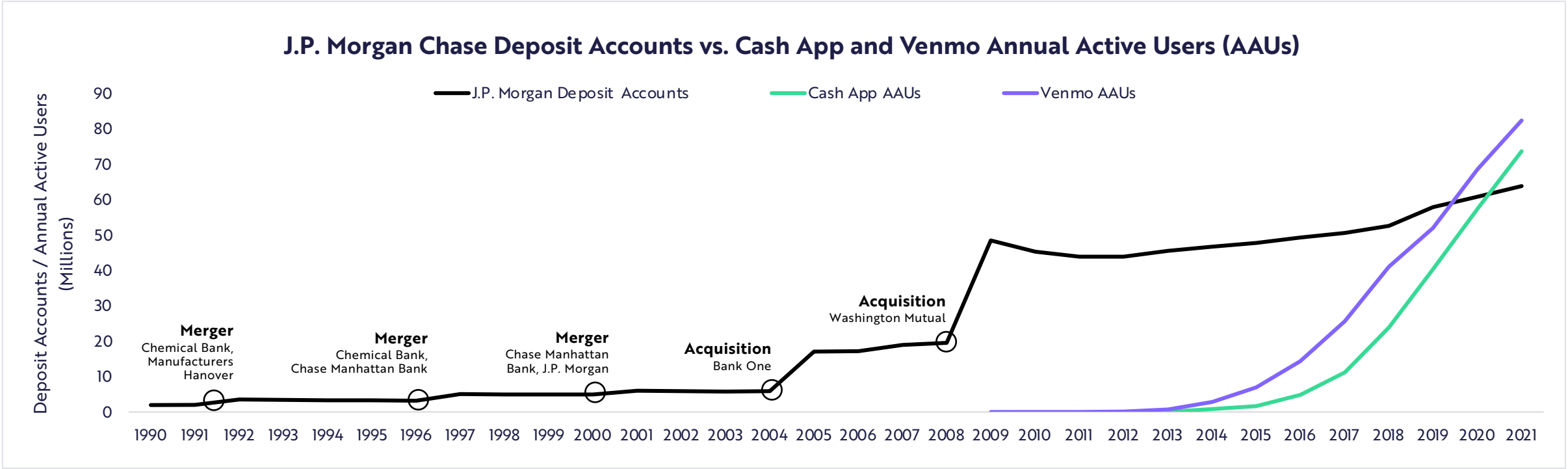




For informational purposes only and should not be considered investment advice, or a recommendation to buy, sell or hold any particular security.
Source: ARK Investment Management LLC, 2021; Worldpay Global Payments Report issues 2017, 2018, 2020, 2021. ARK estimates for 2017.

The Number Of Digital Wallet Users Has Surpassed The Number Of Deposit Account Holders At One Of The Largest US Banks

Based on publicly available data, Square's Cash App and PayPal's Venmo have amassed 74 million and 82 million annual active users in the past 8 and 11 years, respectively. J.P. Morgan hit 60 million deposit account holders after five acquisitions in more than 30 years.[1]



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[1] Refers to number of J.P. Morgan Chase deposit accounts <$100,000 prior to 2010 and number of deposit accounts <$250,000 after 2010 due to changing reporting regulation.
Source: ARK Investment Management LLC, 2021, based on data sourced from: Federal Deposit Insurance Corporation (FDIC) Statistics on Depository Institutions (SDI) and RIS.

Digital Wallets Are Differentiated By Customer Acquisition Strategies

Customer Acquisition	Peer-to-Peer (P2P)	Land and Expand	Vertical Integration into Financial Services	Merchant-First
Market Structure	Developed or developing markets suffering from friction in P2P or cross-border payments	Developed or developing markets with opportunities to optimize a single use case in financial services	Developing markets with low financial services penetration	Mostly developed markets with well-established financial services, making (P2P) payments an unattractive customer acquisition strategy
Strategy	Growing P2P networks organically, sometimes accelerated by partnerships with brands or influencers	Leveraging trust with customers to cross-sell other products	Expanding into financial services, often with giveaways or rewards	Using relationships with established merchants to acquire retail customers, mostly through cash-back campaigns
Examples	Cash App, venmo, toss, Chipper	nubank, TINKOFF, momo, Kaspi.kz	WeChat Pay, GrabPay, gopay, mercado pago	satispay, PayPay

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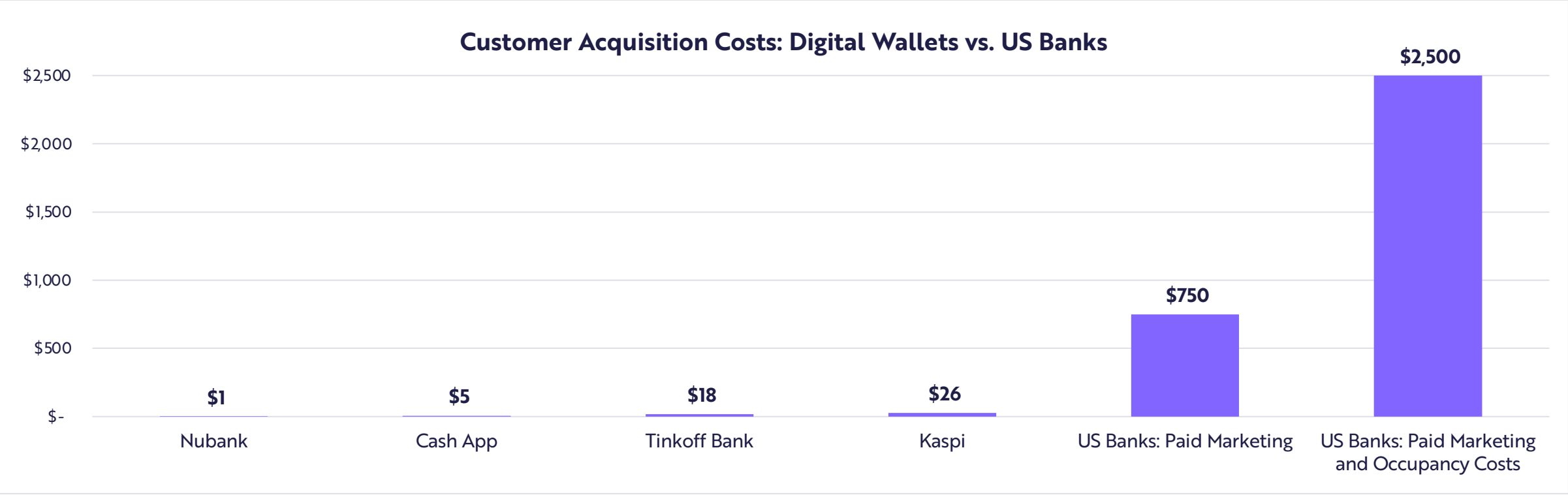
Source: ARK Investment Management LLC, 2021

Differentiated Customer Acquisition Strategies Result In Lower Customer Acquisition Costs

On a net basis, traditional banks in the US spend roughly $750 in paid marketing and roughly $2500 in total, including the occupancy expenses for branch networks, to acquire a new customer

Based on network effects, viral marketing, and arguably superior value propositions, digital wallet providers spend as little as $1 to acquire new customers, giving them room to invest and move up-market.



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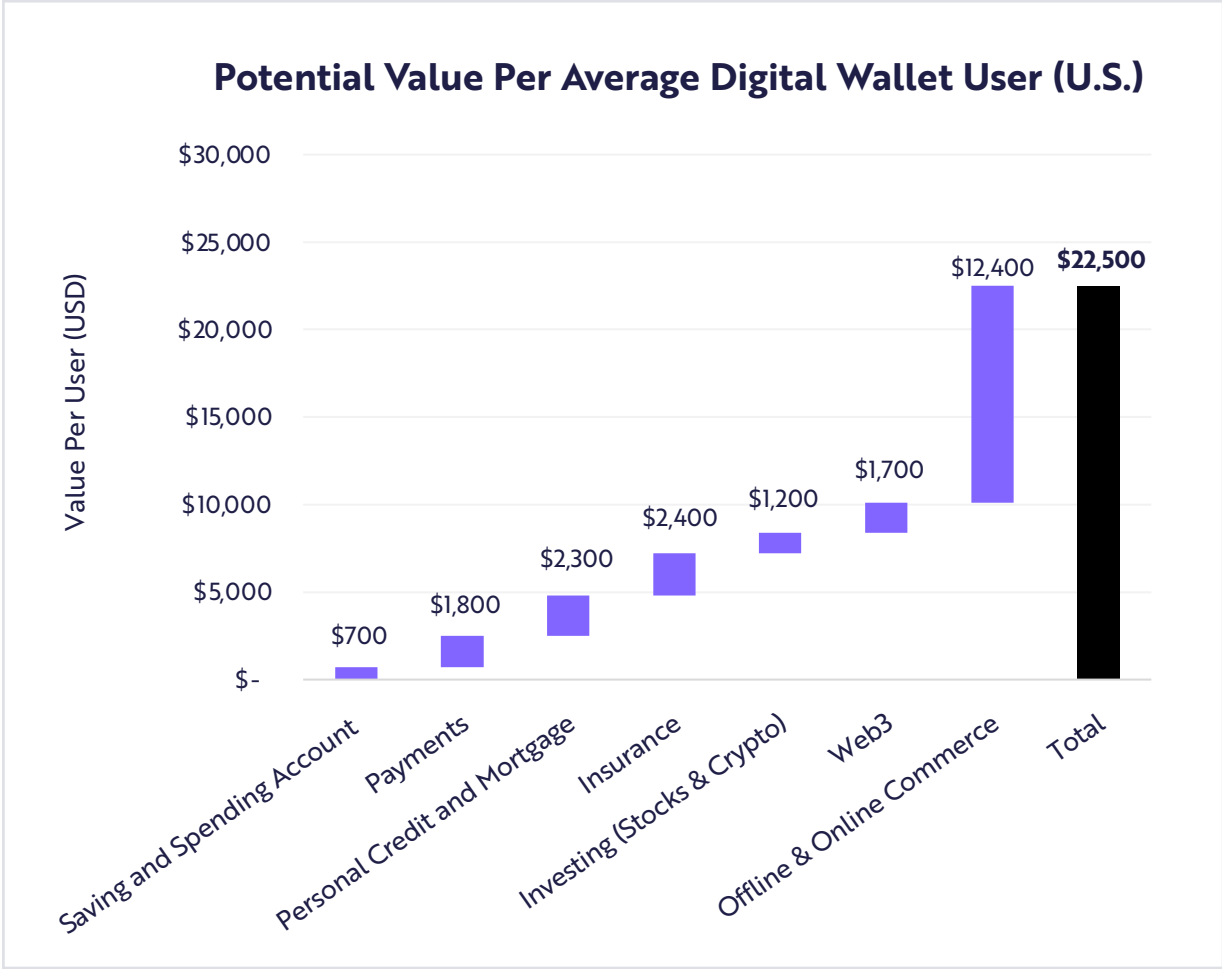
Source: ARK Investment Management LLC, 2021, Company information and ARK Estimates

Each Digital Wallet User In The US Could Be Worth $22,500 At Maturity

If digital wallets were to become consumer financial dashboards, ARK estimates that the net present value of their financial service revenues would be roughly $10,000 per average US user.

Beyond financial services, digital wallets could become lead-generation platforms for offline and online commerce, potentially adding more than $12,000 to their net present value per user.

Digital wallets also could serve as on-ramps to Web3 assets, such as NFTs. ARK estimates that such Web3 monetization could add $1,700 to their net present value per user.



Forecasts are inherently limited and cannot be relied upon. | For informational purposes only and should not be considered investment advice, or a recommendation to buy, sell or hold any particular security. Source: ARK Investment Management LLC, 2021. All net present value estimates based on 2020 or 2021, except web3. Offline/Online Commerce assumes digital wallet captures lead generation fee for 100% of offline and online average US consumer retail spend. Insurance assumes digital wallet captures lead generation fee on average insurance revenue per US consumer. Saving and Spending Account assumes digital wallet captures spread between interest rate and risk-free rate for average balance of US transaction accounts as defined by the Federal Reserve or lead generation fee on net interest income. Offline and Online Payments assumes digital wallet captures fee on 100% of offline and online average US consumer retail spend. Personal credit and mortgage assumes digital wallet captures spread between interest rate and risk-free rate for interest income from average debt per adult in US or or lead-generation fee on net interest income. Investing assumes digital wallet captures revenue (excluding commissions) from average US brokerage and cryptocurrency exchange consumer. Web3 assumes digital wallet captures lead-generation or first party marketplace fee on 100% of 2026 web3 Gross Merchandise Value as forecasted by ARK.

The US Digital Wallet Opportunity Could Scale 69% At An Annual Rate From More Than $400 Billion In 2021 To $5.7 Trillion In 2026.

Digital Wallet Penetration of Smartphone Users 2026 (US)	Digital Wallet Users 2026 (US)	Potential Value per Digital Wallet User (US)	Penetration of Potential Value per Digital Wallet User					
			5%	10%	25%	50%	75%	100%
			Digital Wallet Opportunity (US)					
50%	127 Million	 $22,500	$140 Billion	$290 Billion	$710 Billion	$1.4 Trillion	$2.1 Trillion	$2.8 Trillion
75%	190 Million		$210 Billion	$420 Billion	$1 Trillion	$2.1 Trillion	$3.2 Trillion	$4.2 Trillion
100%	250 Million		$290 Billion	$570 Billion	$1.4 Trillion	$2.8 Trillion	$4.2 Trillion	$5.7 Trillion

If every US smartphone user, valued at $22,500 per user, would adopt a digital wallet by 2026.

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Source: ARK Investment Management LLC, 2021.

The Global Digital Wallet Opportunity Could Scale 78% At An Annual Rate From $1.1 Trillion To $20 Trillion In 2026.

Digital Wallet Penetration of Smartphone Users 2026 (Global)	Digital Wallet Users 2026 (Global)	Potential Value per Digital Wallet User (Global) [1]	Penetration of Potential Value per Digital Wallet User					
			5%	10%	25%	50%	75%	100%
			Digital Wallet Opportunity (Global)					
50%	2.7 Billion	$3,800	$500 Billion	$1 Trillion	$2.5 Trillion	$5 Trillion	$7.7 Trillion	$10 Trillion
75%	4.1 Billion		$750 Billion	$1.5 Trillion	$3.8 Trillion	$7.7 Trillion	$12 Trillion	$15 Trillion
100%	5.4 Billion		$1 Trillion	$2 Trillion	$5 Trillion	$10 Trillion	$15 Trillion	$20 Trillion

[1] Applying ratio of Global GDP per Capita to US GDP per Capita to Potential Value per Digital Wallet User in US to estimate Global Potential Value per Digital Wallet User

If every global smartphone user, valued at $3,800 per user, would adopt a digital wallet by 2026.

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Source: ARK Investment Management LLC, 2021.

ARK INVEST

Public Blockchains

Enabling a Coordination Revolution

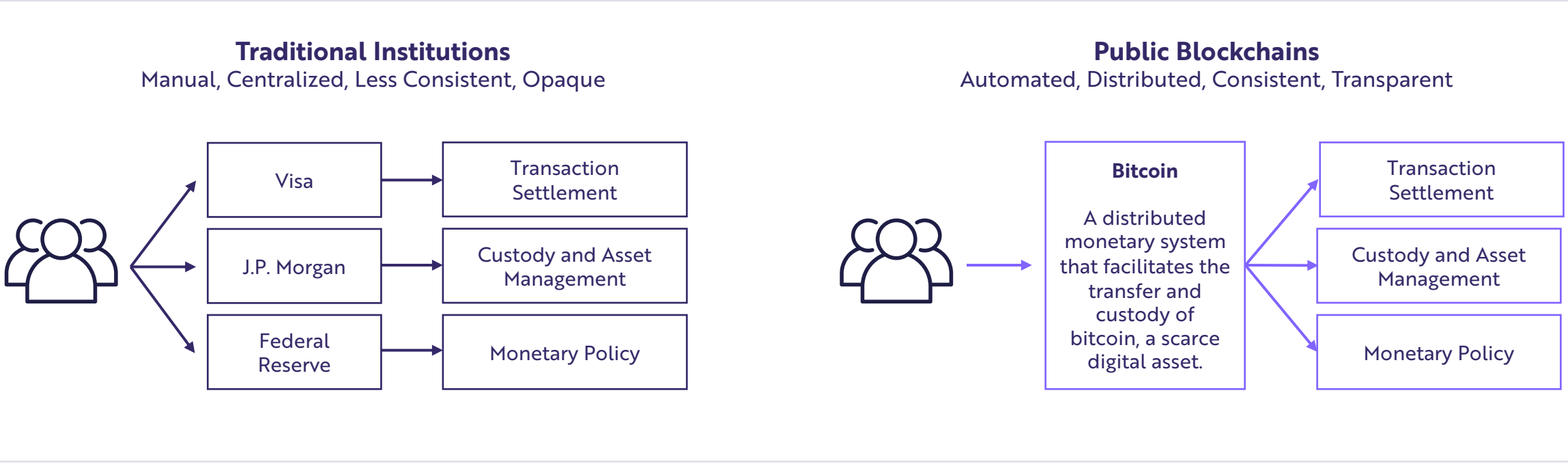
Research by Yassine Elmandjra and Frank Downing, ARK Analysts, and Nishita Jain, ARK Research Associate

Public blockchains are powering novel forms of coordination across money, finance, and the internet. By decentralizing institutions with open-source software, blockchain technology minimizes the need to trust centralized authorities.

We believe bitcoin is the most profound application of public blockchains, the foundation of "self-sovereign" digital money. The Bitcoin protocol has enabled two other revolutions: The Financial (DeFi) and Internet (Web3) Revolutions.

Public Blockchains Minimize The Need To Trust Centralized Authorities

Public blockchains shift the distribution of trust, replacing institutions that rely on centralized authorities with decentralized, open-source software. The first profound application was self-sovereign, digital money (bitcoin). While centralized institutions must coordinate the functions of a financial system, Bitcoin operates as a single, decentralized institution. Instead of relying on accountants, regulators, and governments, Bitcoin relies on a global network of peers to enforce rules.



Note: Each entity presented above is a representative sample of a "name brand" in their respective verticals.
Forecasts are inherently limited and cannot be relied upon. | For informational purposes only and should not be considered investment advice, or a recommendation to buy, sell or hold any particular security/cryptocurrency.
Source: ARK Investment Management LLC, 2021

Public Blockchains Have Unique Characteristics

Public blockchain infrastructure serves as the backbone for new forms of economic coordination: it minimizes the need to trust centralized institutions. The decentralized, open, and permissionless characteristics of public blockchains lower the cost of coordination, among other advantages.

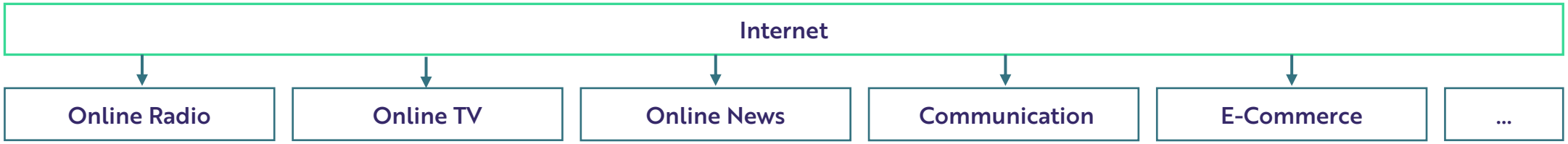
Status Quo Infrastructure		Public Blockchain Infrastructure	
Centralized	Central authorities mediate network activity	**Decentralized**	Distributed computer nodes mediate network activity
Closed-Source	Network rules are determined behind closed doors at the discretion of companies, platforms, and regulators	**Open-Source**	Network rules are open and auditable, coordinated by users and stakeholders
Corporate-Run	Corporations facilitate coordination, often excluding network participants	**User-Run**	Network participants facilitate coordination through a fair system of checks and balances
Permissioned	Geography and regulation control access to platforms	**Permissionless**	Anyone with an internet connection can participate and innovate

Source: ARK Investment Management LLC, 2021

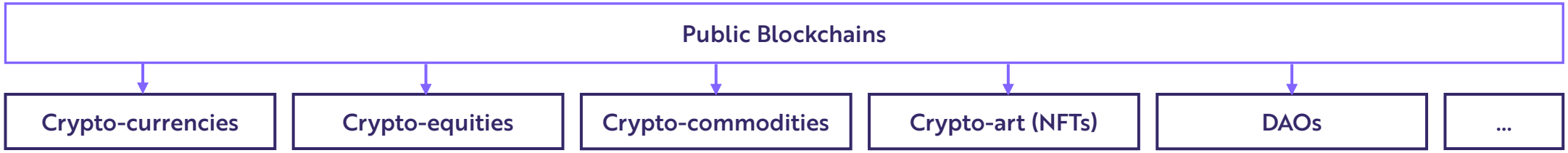
Public Blockchains Could Transform Every Traditional Asset Class

Investors once thought the internet was a new channel among others:

Now, the internet is facilitating ***all*** channels:



Similarly, cryptoassets issued on public blockchains are likely to impact ***all*** asset classes. Just as the internet turned information into packets online, public blockchains are likely to turn all assets into transactions on-chain.



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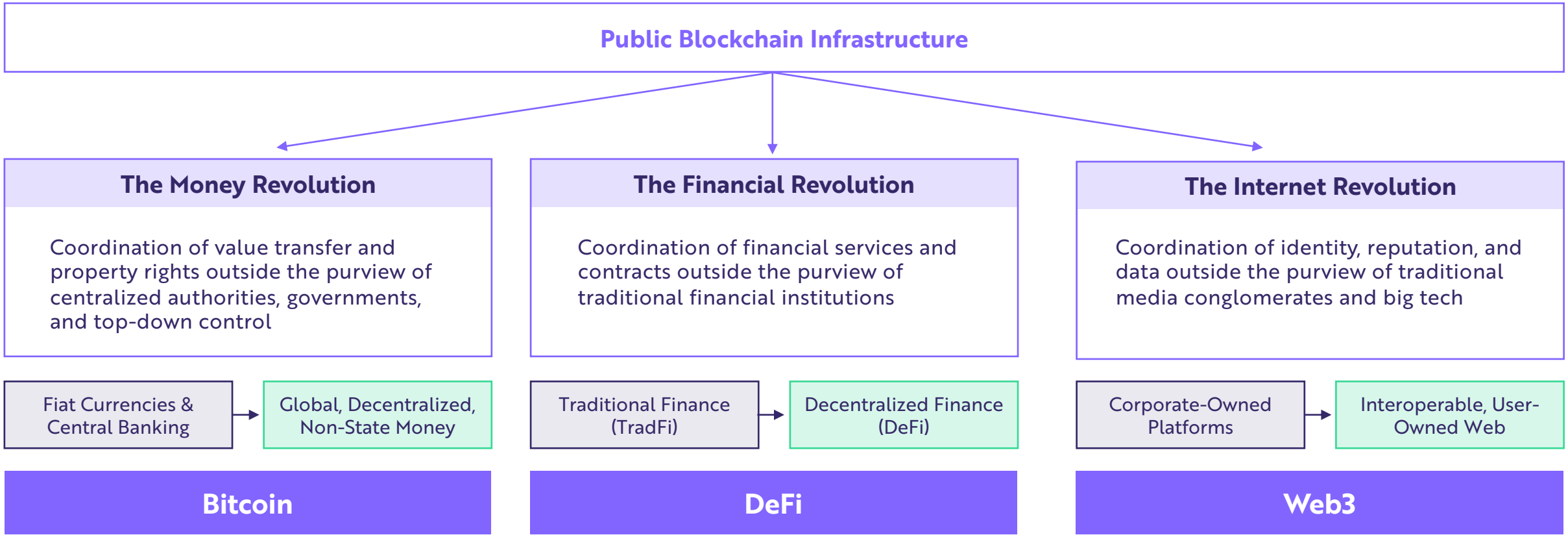
Source: ARK Investment Management LLC, 2021 and Srinivasan, Balaji, Twitter, 23 Apr. 2021, twitter.com/balajis/status/1385572764485001221.

Public Blockchains Are Stirring Several Revolutions

In our view, the Bitcoin protocol created the most profound application of public blockchain infrastructure. In addition to the Money Revolution, public blockchains also have catalyzed Financial and Internet Revolutions.



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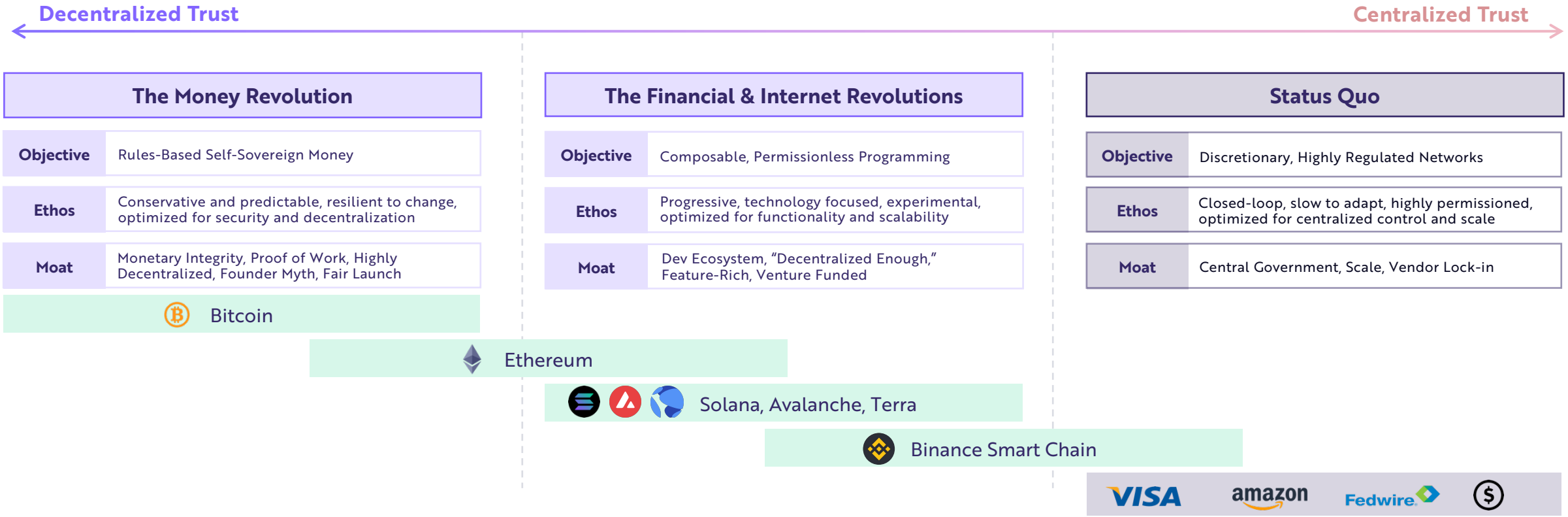
Source: ARK Investment Management LLC, 2021

Each Revolution Involves A Different Level of Trust

In our view, the Money Revolution requires predictable monetary assurances, maximum decentralization, and conservatism. The Financial and Internet Revolutions require some tradeoffs to achieve scalability, convenience, and innovation. Competing blockchains should recognize that too much trust in centralized authorities risks a reversion to the status quo.



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Source: ARK Investment Management LLC., 2021

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ARK INVEST

Bitcoin

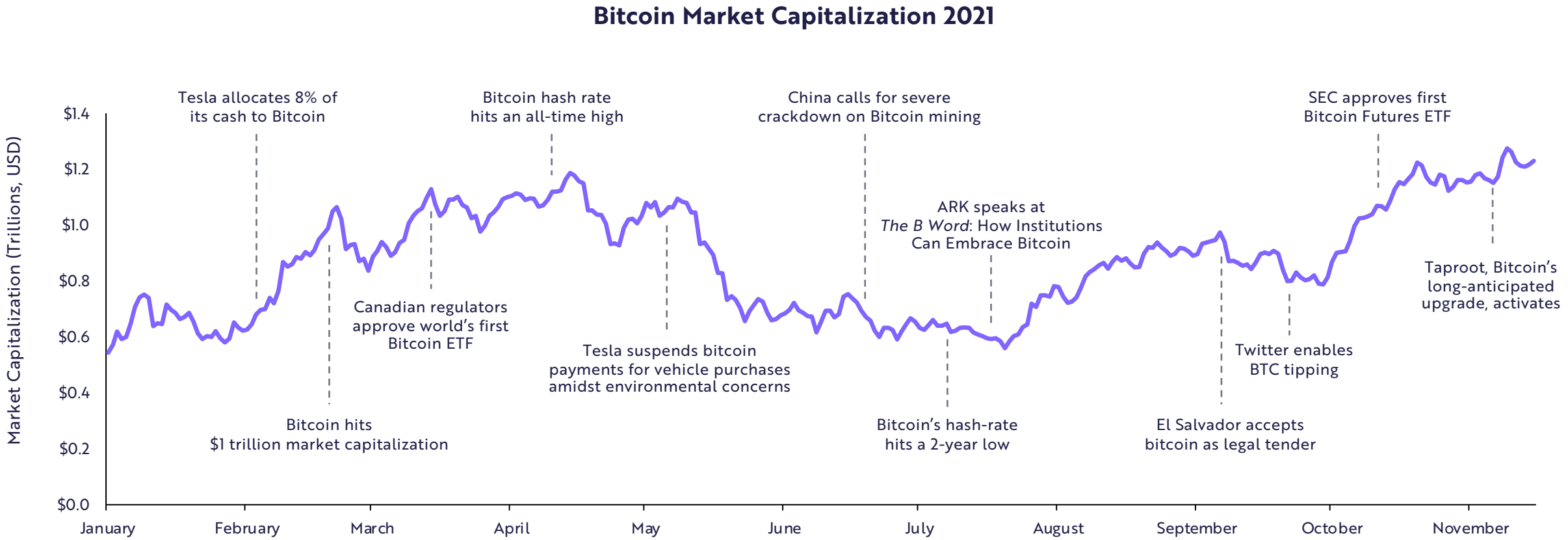
A Monetary Revolution

Research by Yassine Elmandjra, ARK Analyst

As bitcoin's market capitalization hit an all-time high in 2021, ARK's research indicated that its network fundamentals remained healthy.

Bitcoin's market capitalization still represents a fraction of global assets and is likely to scale as nation-states adopt as legal tender. According to our estimates, the price of one bitcoin could exceed $1 million by 2030.

Bitcoin Reached $1 Trillion In Market Capitalization In 2021

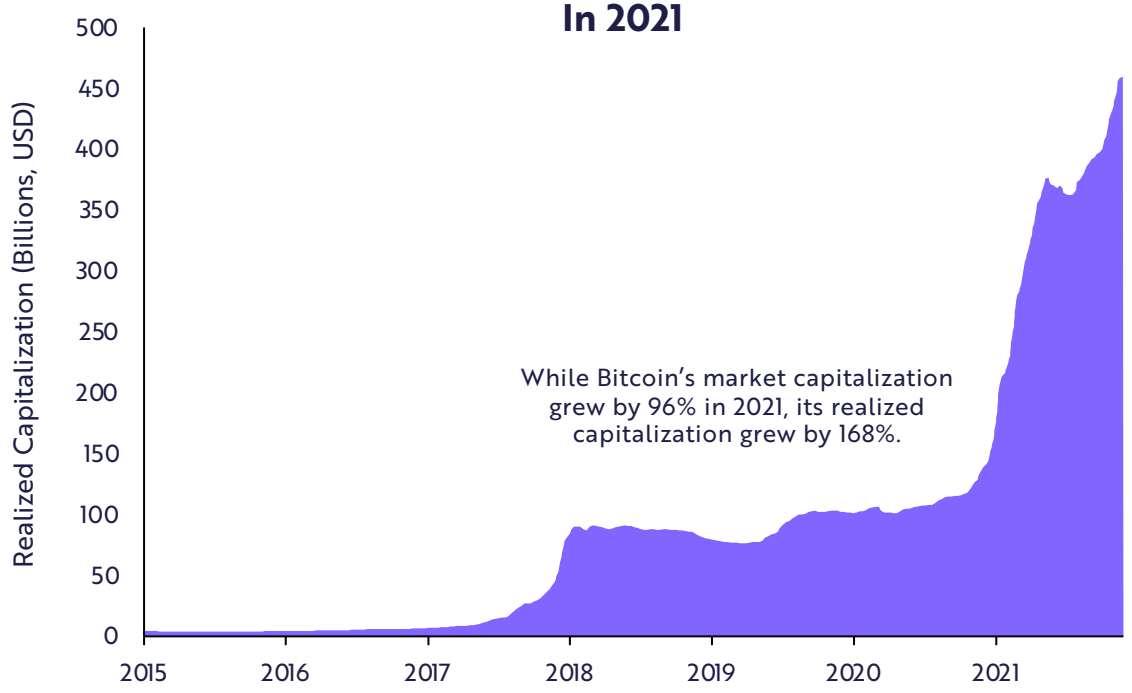


For informational purposes only and should not be considered investment advice, or a recommendation to buy, sell or hold any particular security or cryptocurrency.
Source: ARK Investment Management LLC, 2021 based on data sourced from: Glassnode Pro, Cointelegraph, Feb 8, 2021 https://cointelegraph.com/news/tesla-allocates-7-7-of-gross-cash-to-bitcoin; Mondaq March 18, 2021 https://www.mondaq.com/canada/fin-tech/1047964/canadian-regulators-approve-world39s-first-bitcoin-etf-for-individual-investors, Wall Street Journal May 12 2021 https://www.wsj.com/articles/elon-musk-says-tesla-suspends-accepting-bitcoin-for-vehicle-purchases-11620858838 NPR September 7 2021 https://www.npr.org/2021/09/07/1034838909/bitcoin-el-salvador-legal-tender-official-currency-cryptocurrency; Twitter September 23 2021 https://blog.twitter.com/en_us/topics/product/2021/bringing-tips-to-everyone; Coindesk October 15 2021 https://www.coindesk.com/policy/2021/10/15/sec-approves-bitcoin-etf-opening-crypto-to-wider-investor-base/; Coindesk November 12 2021 https://www.coindesk.com/tech/2021/11/13/taproot-bitcoins-long-anticipated-upgrade-activates-this-weekend/

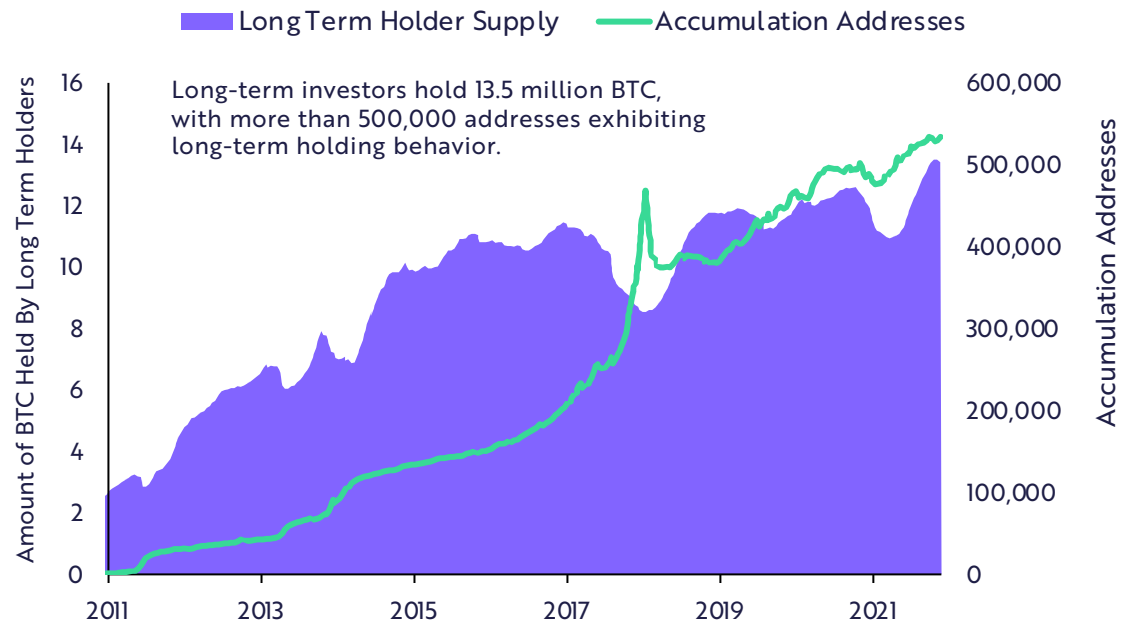
Bitcoin's Market Participants Are Maturing And Focused On The Long-Term

Despite increased exuberance as bitcoin scaled to a record high price, on-chain data suggests that bitcoin holders are focused on long-term fundamentals.

Bitcoin's Aggregate Cost Basis Hit A New Record In 2021



Bitcoin's Long-Term Holder Base Hit An All Time High in 2021



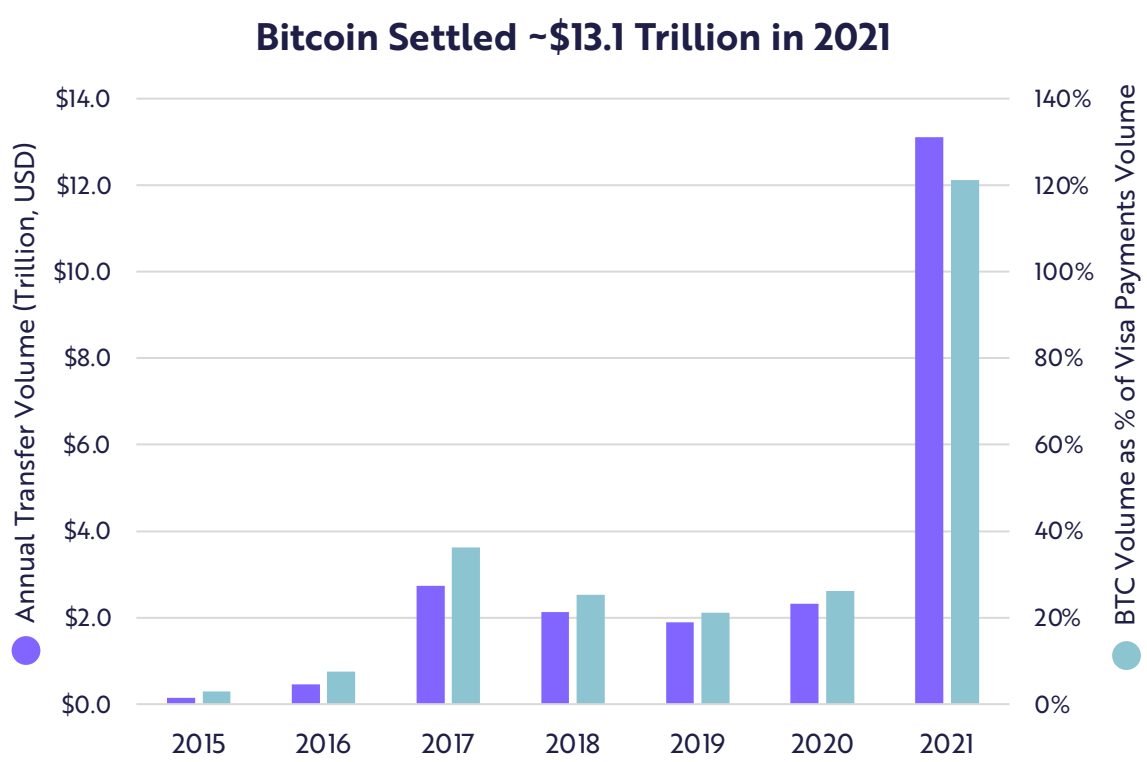
Note: Accumulation addresses are defined as addresses that have at least 2 incoming non-dust transfers and have never spent funds. Note: "Long-term holder base" refers to Bitcoin that has not been moved in 155 days or more. "Bitcoin dust" refers to the very small amounts of bitcoin leftover or unspent in a transaction that is lower in value than the minimum limit of a valid transaction.
For informational purposes only and should not be considered investment advice, or a recommendation to buy, sell or hold any particular security or cryptocurrency.
Source: ARK Investment Management LLC, 2021 based on data sourced from: Glasssnode

Bitcoin Is Taking Market Share As A Global Settlement Network

Bitcoin's cumulative transfer volume increased by 463% in 2021. Bitcoin's annual settlement volume has surpassed Visa's payments volume.

Bitcoin's Transfer Value Metrics, On Both An Absolute and Price-Adjusted Basis

Bitcoin Metrics		2020	2021
Cumulative Annual Transfer Volume	$	$2.3 trillion	**$13.1 trillion**
	BTC	212.0 million	**275.4 million**
Average Daily Transfer Volume	$	$6.4 billion	**$35.9 billion**
	BTC	579,190	**754,499**
Average Transaction Value	$	$21,590	**$136,555**
	BTC	1.97	**2.87**



Note: All BTC transfer volume and transaction value metrics are on a change-adjusted basis. ARK's calculation for average change-adjusted transaction value uses both the total and the mean change-adjusted volume metrics aggregated by Glassnode. Visa payments volume is on a nominal-basis as reported by the company. It includes global consumer credit, consumer debit, and commercial payment volumes. Visa 2021 Q4 nominal payments volume is annualized based on historical Q4 quarter-over-quarter growth.

Source: ARK Investment Management LLC, 2021 based on data sourced from: Glasssnode, Visa, and FRB Services

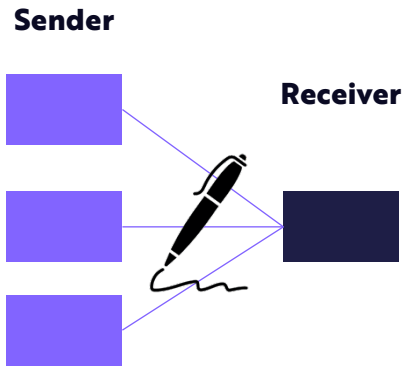
Bitcoin Could Continue To Scale In Response To Technological Breakthroughs

Last year, Bitcoin made conservative, strategic enhancements at the base layer while encouraging experimentation "off-chain."

Successful Soft Fork Activation

Bitcoin activated Taproot, its biggest base-layer protocol upgrade since SegWit in 2017. Along with the introduction of Schnorr signatures, Taproot could increase the privacy and efficiency of Bitcoin transactions.

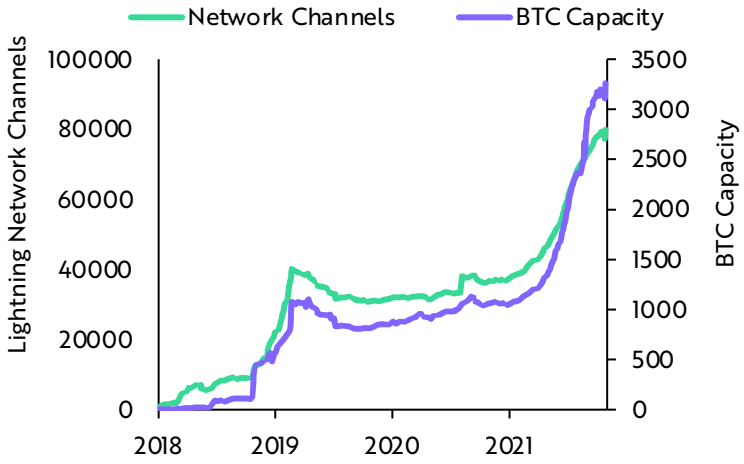
Complex transactions require a single merged signature, greatly reducing the bandwidth and storage burden on the protocol.



"Layer 2" Growth

Lightning Network (LN), a second layer payment protocol built on Bitcoin, saw significant growth. LN channels and BTC capacity on LN increased 119% and 210%, respectively.

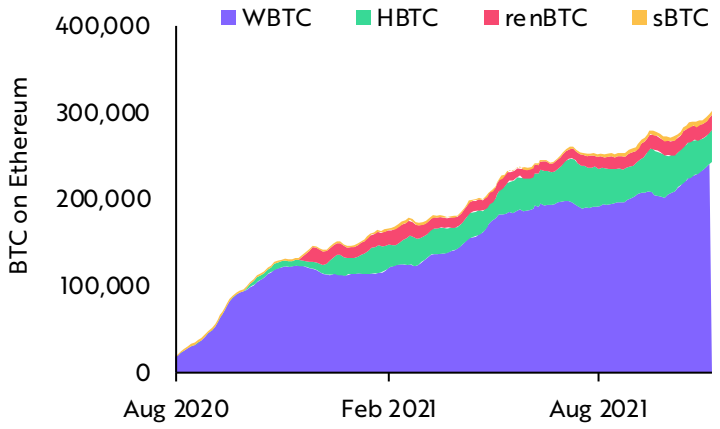
LN Channels and BTC Capacity*



Bitcoin-Denominated DeFi

Tokenized bitcoin on other blockchains provides holders with features and functionality not available on the Bitcoin network. As of Nov. 21, 2021, 315,000 BTC, or 1.5% of Bitcoin's circulating supply, is "wrapped" on Ethereum.

BTC on Ethereum



*BTC Capacity is the total BTC locked across all Lightning Network channels. For informational purposes only and should not be considered investment advice, or a recommendation to buy, sell or hold any particular security or cryptocurrency.
Source: ARK Investment Management LLC, 2021 based on data sourced from: Glasssnode and Coingecko

Bitcoin Is Attracting Institutional Holders

Bitcoin's institutional holder base appears to be broadening after the launch of more regulated products and adoption by corporations and nation-states.

Exchange Traded Products, Countries, and Corporations Held 8% of Bitcoin's Supply As of November 2021

Category	# of Bitcoin	% of Circulating Supply	Value Today ($ billions)
ETPs	816,379	4.32%	$49.0
Countries	263,037	1.39%	$15.8
Public Companies	231,781	1.23%	$13.9
Private Companies	174,068	0.92%	$10.4
Total	**1,494,824**	**7.91%**	**$89.7**

Grayscale Bitcoin Trust Remains The Largest Non-Custodian Bitcoin Holder As of November 2021

Ten Largest Publicly Disclosed Bitcoin Holders

	Holder	Type	BTC
1.	Grayscale Bitcoin Trust	ETP	654,200
2.	Block.one	Balance Sheet	140,000
3.	Microstrategy	Balance Sheet	121,044
4.	Coinshares XBT Provider	ETP	48,466
5.	Tesla Inc.	Balance Sheet	42,902
6.	Purpose Bitcoin ETF	ETP	24,097
7.	3IQ Coinshares ETF	ETP	22,010
8.	ETC Group Bitcoin ETP	ETP	17,976
9.	The Tezos Foundation	Balance Sheet	17,500
10.	Galaxy Digital	ETP	16,400

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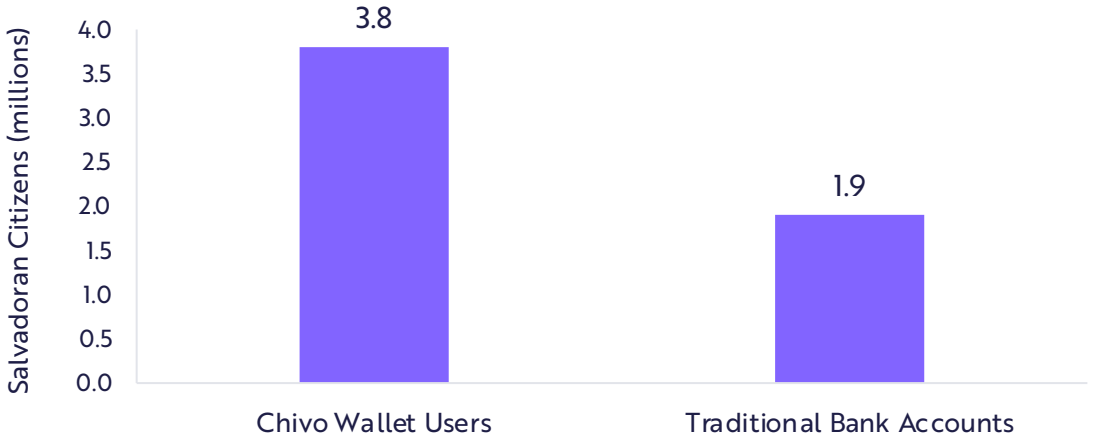
Source: ARK Investment Management LLC, 2021 based on data sourced from: https://www.buybitcoinworldwide.com/treasuries/

El Salvador Is The First Nation-State To Adopt Bitcoin As Legal Tender

In El Salvador, More People Have Bitcoin Wallets Than Traditional Bank Accounts



- In September, El Salvador became the first country to adopt bitcoin as legal tender.
- As of December 31, 2021, El Salvador had purchased 1,391 BTC.
- An estimated 3.8 million people use El Salvador's Bitcoin wallet, *Chivo*, suggesting 84% adoption among eligible citizens.
- *Chivo* was settling $2 million in remittances daily as of October 2021, accounting for roughly 12% of El Salvador's $6 Billion in annual remittances and more than 2% of its GDP.

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Source: ARK Investment Management LLC, 2021 based on data sourced from: Forbes, Salvadoran President Nayib Bukele's Twitter Feed https://twitter.com/nayibbukele

Concerns About Bitcoin's Lack Of Sustainability Seem Ill-Informed

Our research suggests that Bitcoin has the potential to transform monetary history by providing financial freedom and empowerment in a fair, global, and distributed way.

Environmental

Bitcoin incentivizes new and more efficient forms of energy generation.

Bitcoin mining can capture natural gas that otherwise would be vented or flared.

Bitcoin mining can encourage investment in intermittent energy systems, increasing renewables share of energy provisioned to the grid.

Social

Bitcoin offers a system of property rights without reliance on nation-states, protecting the purchasing power of people in countries with strict capital controls, highly inflationary currencies, or capricious governments.

Bitcoin is open to anyone as it does not rely on a centralized authority to determine the eligibility of participants.

Governance

Bitcoin is open, transparent, auditable, and predictable.

Bitcoin has no central point of failure and reduces potential human bias and error.

Bitcoin incorporates a unique system of checks and balances intended to encourage protocol innovation and maintenance, ensuring that any changes are in the interest of stakeholders.

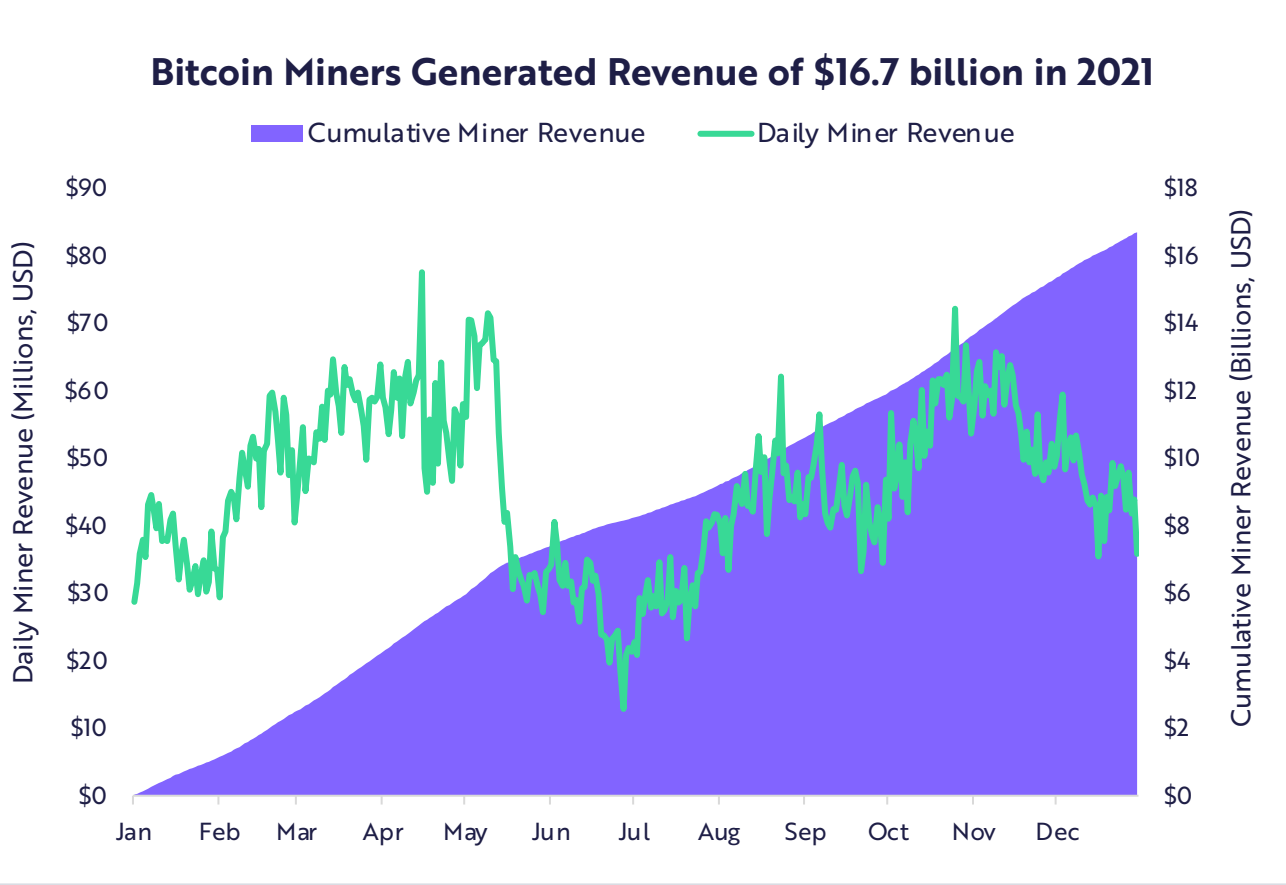
Forecasts are inherently limited and cannot be relied upon. | For informational purposes only and should not be considered investment advice, or a recommendation to buy, sell or hold any particular security or cryptocurrency.
Source: ARK Investment Management LLC, 2021.

Bitcoin Mining Has Evolved Into A Multibillion Dollar Industry

Converting energy into a monetary asset can be critical in times of geopolitical uncertainty and financial market volatility.

A Digital-Monetary Energy Network

- Bitcoin's innovative potential rests in its ability to facilitate the transfer of value without relying on a centralized authority. The key enabler is proof-of-work mining.
- Bitcoin incentivizes the discovery of cost-efficient energy sources, independent of location and consumer demand.
- Following China's crackdown on mining, the US has emerged as the leader in Bitcoin mining, accounting for more than 35% of total hash rate as of November 2021.
- Nation-states like El Salvador are investing heavily in Bitcoin mining infrastructure. In October 2021, El Salvador announced the mining of bitcoin with energy from its volcanos, three months after instructing state-owned geothermal electric company La Geo to plan for bitcoin mining.



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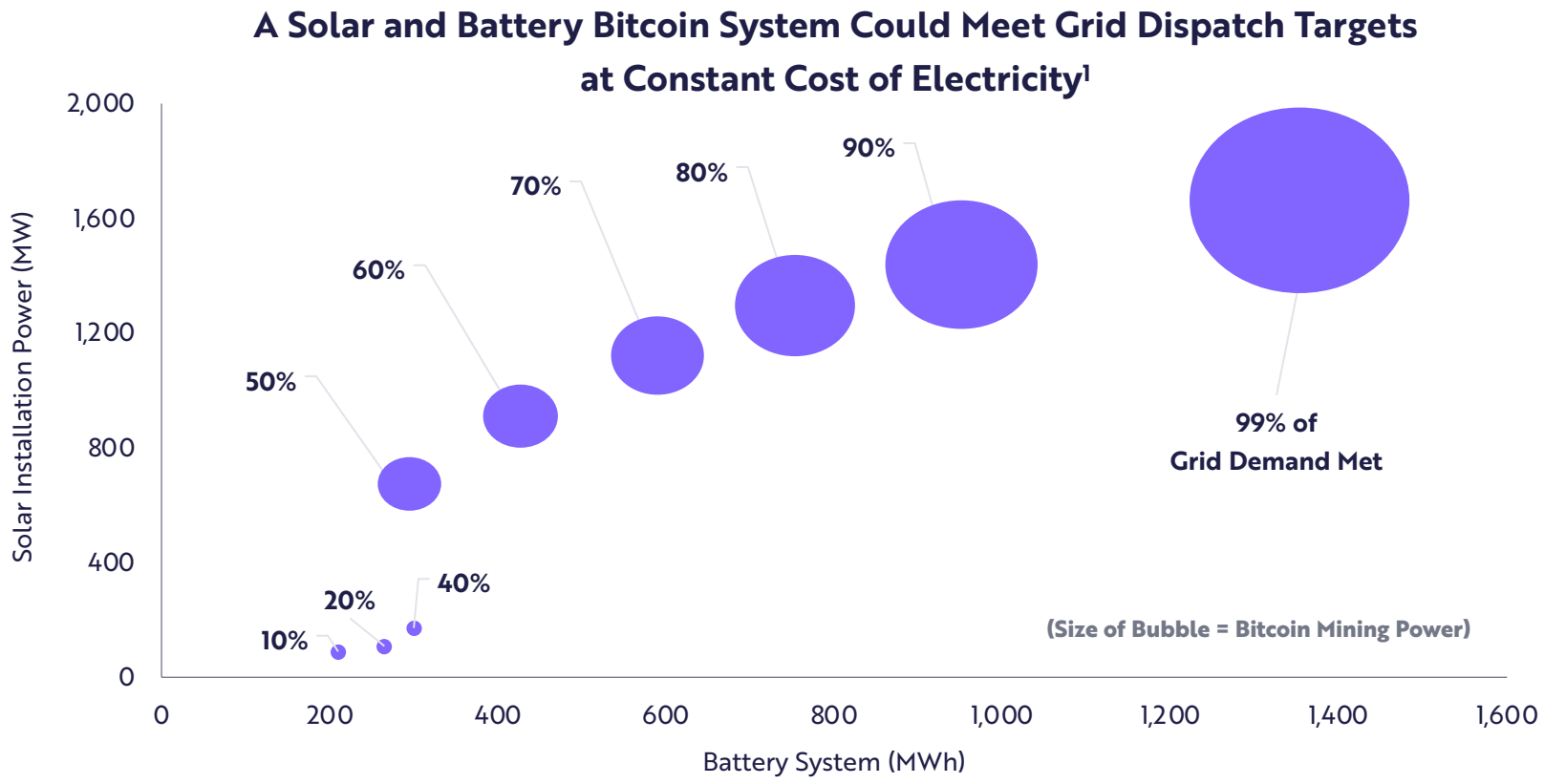
Source: ARK Investment Management LLC, 2021, based on data sourced from: Glassnode, CBECI

Bitcoin Mining Could Revolutionize Energy Production

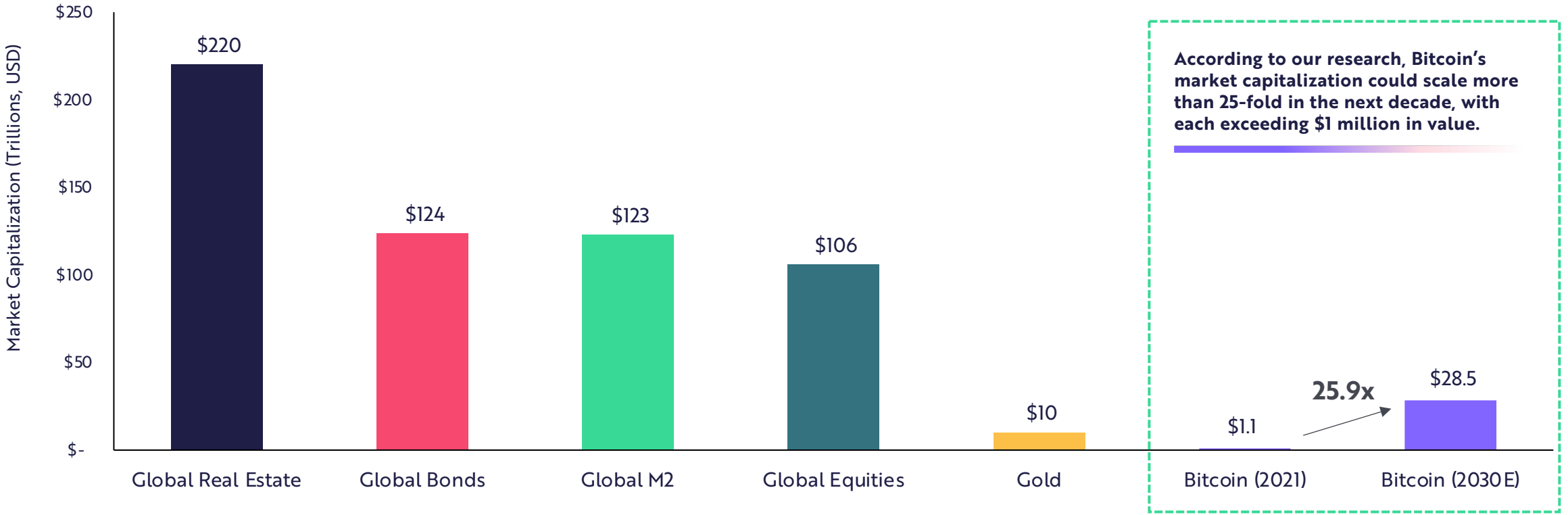
According to our research, bitcoin mining will encourage and generate more electricity from renewable carbon-free sources.

- As energy buyers, Bitcoin miners could incentivize new and more efficient forms of energy generation.
- According to ARK's research, intermittent energy sources like wind and solar could meet a larger percentage of grid demand if Bitcoin mining impacts the utility grid.
- Energy asset owners could become bitcoin miners.
- The addition of Bitcoin mining into power developers' toolboxes should increase the overall addressable market for renewable and intermittent power sources. In the bottom left of the chart, in the absence of Bitcoin mining, renewables might satisfy only 40% of the grid's needs. In the top right of the chart, with the introduction of Bitcoin mining, solar and batteries could satisfy 99% of the grid's demand.



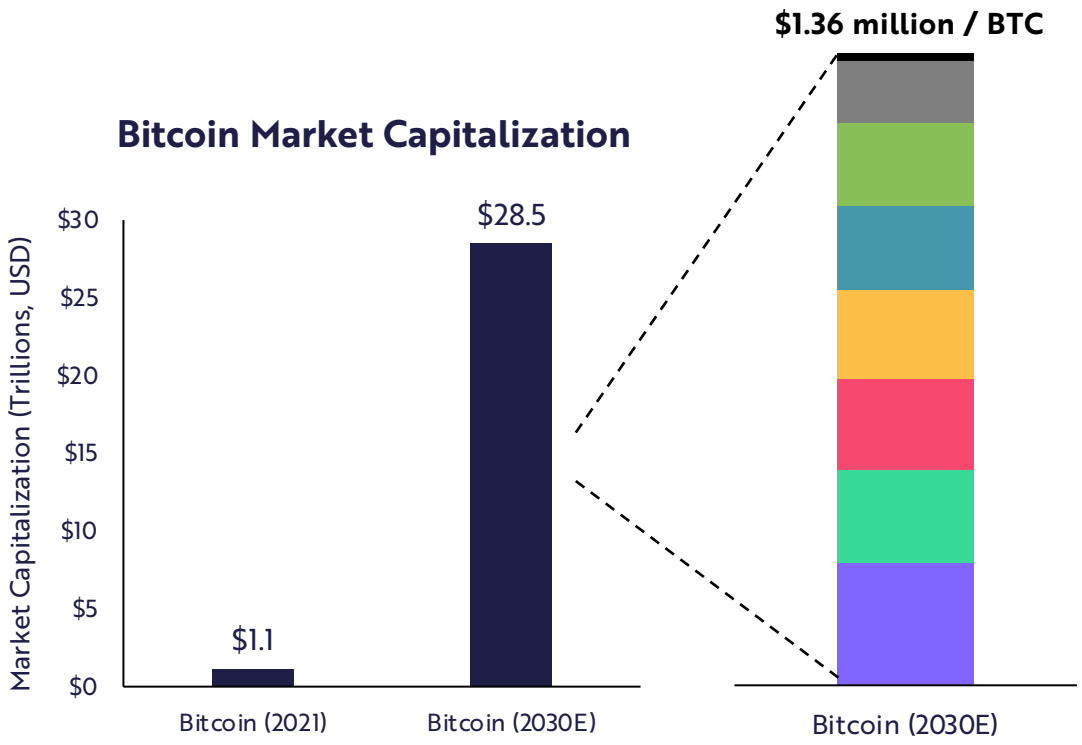
[1] Note: The addition of Bitcoin mining into power developers' toolboxes should increase the overall addressable market for renewable and intermittent power sources. In the bottom left of the chart, in the absence of Bitcoin mining, renewables can satisfy only 40% of the grid's needs. In the top right of the chart, including Bitcoin mining, solar and batteries can satisfy 99% of the grid's demand.For informational purposes only and should not be considered investment advice, or a recommendation to buy, sell or hold any particular security or cryptocurrency. Source: ARK Investment Management LLC, 2021.

Now A Fraction Of Global Asset Values, Bitcoin Has Significant Appreciation Potential



Forecasts are inherently limited and cannot be relied upon. | For informational purposes only and should not be considered investment advice, or a recommendation to buy, sell or hold any particular security or cryptocurrency.
Source: ARK Investment Management LLC, 2021.

The Price Of One Bitcoin Could Exceed $1 Million by 2030



Bitcoin Use Case	Market Cap	Value per BTC
Remittance Network *50% of global remittances at 1.5x velocity*	**$0.3 trillion**	**$14,000 / BTC**
Emerging Market Currency *10% of M2 (excludes top 4 countries)*	**$2.8 trillion**	**$133,000 / BTC**
Economic Settlement Network *25% of US bank settlement volumes*	**$3.8 trillion**	**$181,000 / BTC**
Nation-State Treasury *1% of total reserves*	**$3.8 trillion**	**$181,000 / BTC**
Seizure-Resistant Asset *5% of global HNWI wealth*	**$4.0 trillion**	**$190,000 / BTC**
Institutional Investment *2.55% of institutional asset base*	**$4.1 trillion**	**$196,000 / BTC**
Corporate Treasury *5% of cash of S&P 500 companies*	**$4.2 trillion**	**$200,000 / BTC**
Digital Gold *50% of gold's total market capitalization*	**$5.5 trillion**	**$260,000 / BTC**
	$28.5 trillion	**$1.36 million / BTC**

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Source: ARK Investment Management LLC, 2021. | Corporate Treasury Data Source: Capital IQ, Seizure Resistant Asset Data Source: https://worldwealthreport.com/wp-content/uploads/sites/7/2021/07/World-Wealth-Report-2021.pdf, Remittances Market Data Source: https://thefintechtimes.com/global-remittance-market-is-expected-to-grow-by-200-billion-by-2026/ , Nation State Treasury Data Source: https://data.worldbank.org/indicator/FI.RES.TOTL.CD?end=2020&start=2002 Note: a 25x price multiplier was applied to Nation-state treasury and corporate treasury opportunities. The price multiplier is the upper bound estimate made by Chris Burniske (Co-author of Cryptoassets: The Innovative Investor's Guide to Bitcoin and Beyond and Partner at VC firm Placeholder), which roughly equates to the average between the estimated lower bound made by Burniske and the estimated upper bound made by Citi Bank https://medium.com/@cburniske/cryptoassets-flow-amplification-reflexivity-7e306815dd8c

ARK INVEST

Ethereum & DeFi

A Financial Revolution

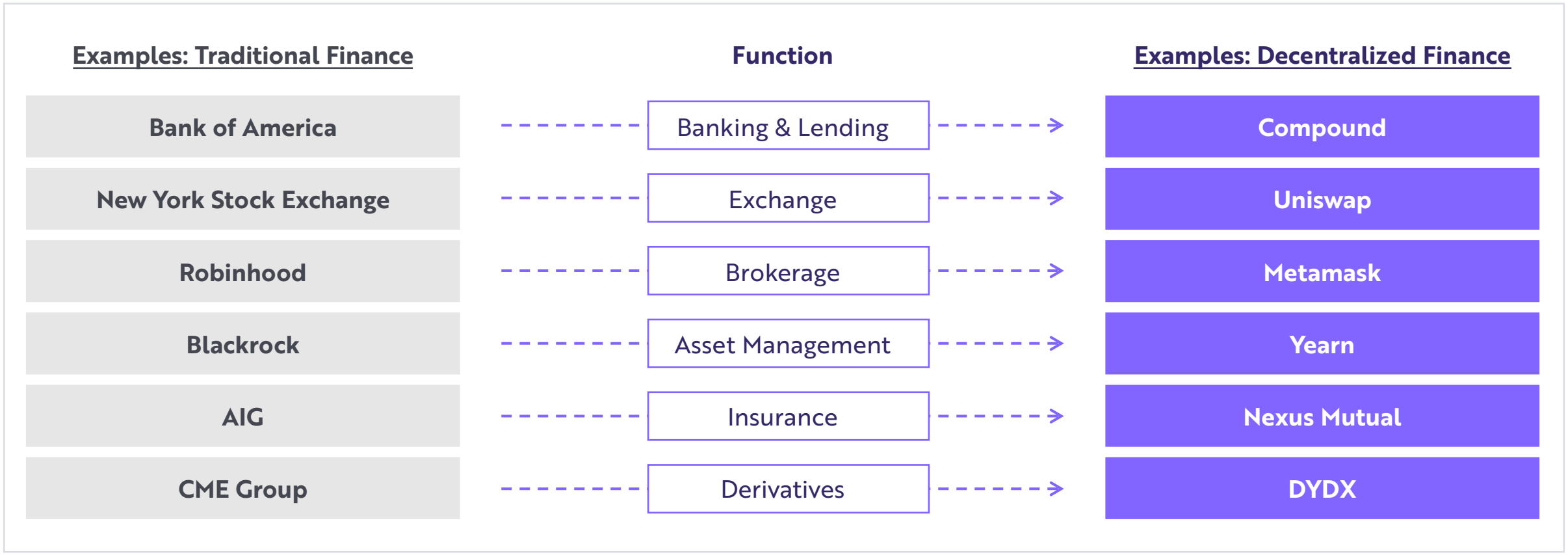
Research by Frank Downing, ARK Analyst, and Nishita Jain, ARK Research Associate

Decentralized Finance (DeFi) promises more interoperability, transparency, and financial services while minimizing intermediary fees and counterparty risk. After a turbulent 2018-2019, Ethereum emerged in 2021 as the predominant smart contracting platform for decentralized finance and non-fungible tokens (NFTs).

According to ARK's research ether (ETH) is both the preferred collateral in DeFi and the unit of account in NFT marketplaces, suggesting that it is likely to capture a portion of the $123 trillion global money supply.

Smart Contracts Are Usurping Traditional Financial Functions At The Margin

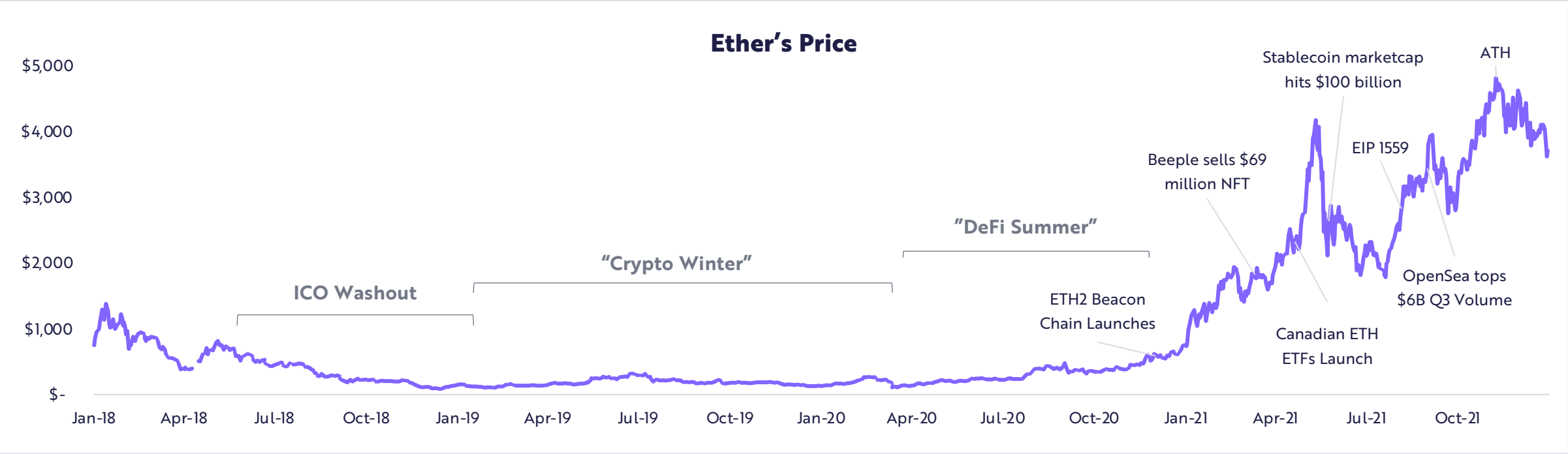
Smart contracting platforms like Ethereum are open and transparent. They do not rely on traditional financial intermediaries, thereby reducing counterparty risk.



Note: Each entity presented above is a representative sample of a "name brand" in their respective verticals.
For informational purposes only and should not be considered investment advice, or a recommendation to buy, sell or hold any particular security or cryptocurrency.
Source: ARK Investment Management LLC, 2021 based on data sourced from: "Defi Report Q1 2021." *Consensys*, https://consensys.net/reports/defi-report-q1-2021.

Ether Hit New Highs In Response To DeFi and NFTs

Built on Ethereum, DeFi, stablecoins, and NFTs pushed ether to an all time high in late 2021. Since the speculative ICO washout in 2018, Ethereum's activity has evolved considerably.



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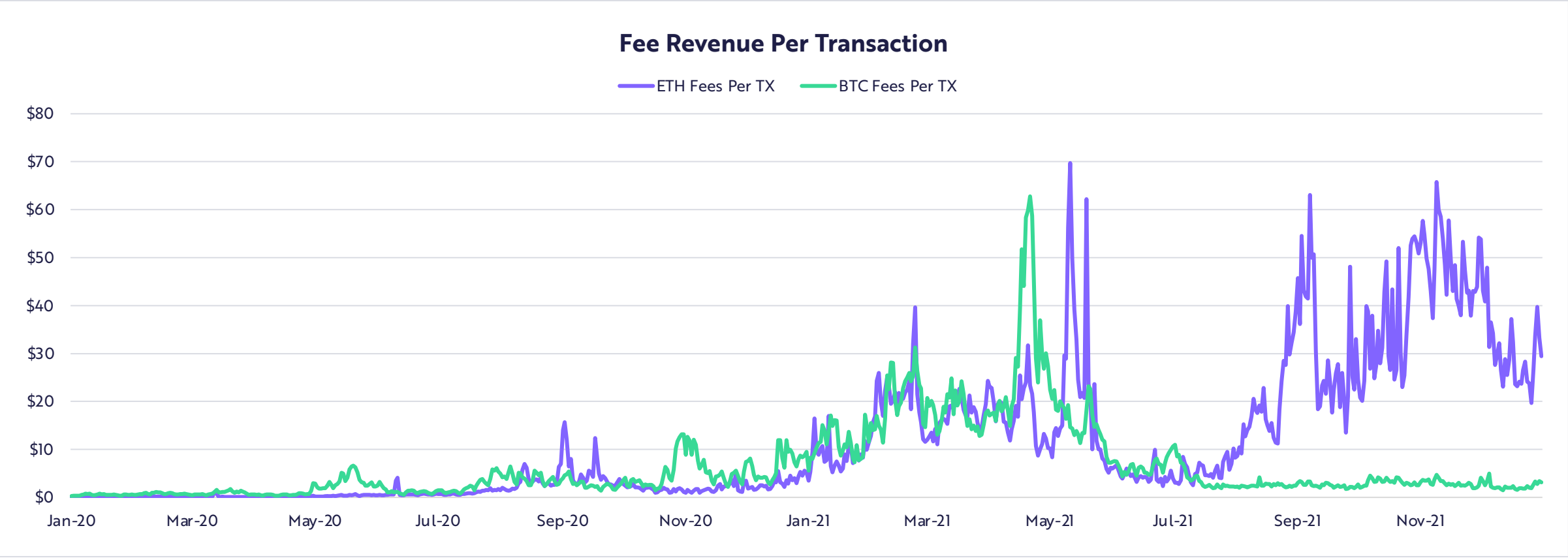
Source: ARK Investment Management LLC, 2021 based on data sourced from: "The Beacon Chain." Ethereum.org, Ethereum Foundation, 7 July 2021, https://ethereum.org/en/eth2/beacon-chain/; DiCamillo, Nate. "Canada Approves Three Ethereum Etfs in One Day." CoinDesk Latest Headlines RSS, CoinDesk, 16 Apr. 2021, https://www.coindesk.com/markets/2021/04/16/canada-approves-three-ethereum-etfs-in-one-day/; "Ethereum: Price." Glassnode, https://studio.glassnode.com/metrics?a=ETH&category=&m=market.PriceUsdClose; Kastrenakes, Jacob. "Beeple Sold an NFT for $69 Million." The Verge, The Verge, 11 Mar. 2021, https://www.theverge.com/2021/3/11/22325054/beeple-christies-nft-sale-cost-everydays-69-million; "NFT Marketplace Monthly Volume." The Block, https://www.theblockcrypto.com/data/nft-non-fungible-tokens/marketplaces/nft-marketplace-monthly-volume; Sigalos, MacKenzie. "Ethereum Just Activated a Major Change Called the 'London Hard Fork' - Here's Why It's a Big Deal." CNBC, CNBC, 5 Aug. 2021, https://www.cnbc.com/2021/08/05/ethereum-just-activated-its-london-hard-fork-and-its-a-big-deal.html; "Total Stablecoin Supply." The Block, https://www.theblockcrypto.com/data/decentralized-finance/stablecoins/total-stablecoin-supply-daily;

Increased Network Activity Has Pushed Ethereum's Transaction Fees Higher Than Those For Bitcoin

Higher fees have created demand for "Layer 2" scaling solutions to lower Ethereum's transaction fees while maintaining security.



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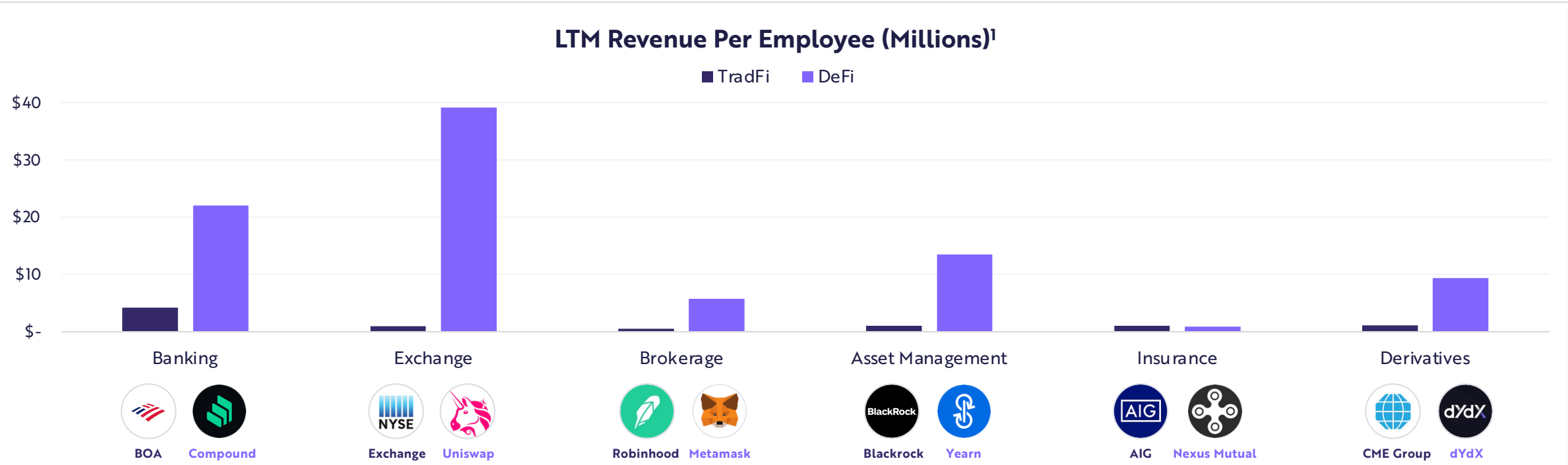
Source: ARK Investment Management LLC, 2021 based on data sourced from: Glassnode

Crypto-Powered Finance Might Scale More Efficiently Than Traditional Finance

Smart contract-based financial transactions settle in near real-time almost anywhere in the world. Revenue per employee illustrates DeFi's efficiency relative to that of traditional finance (TradFi).



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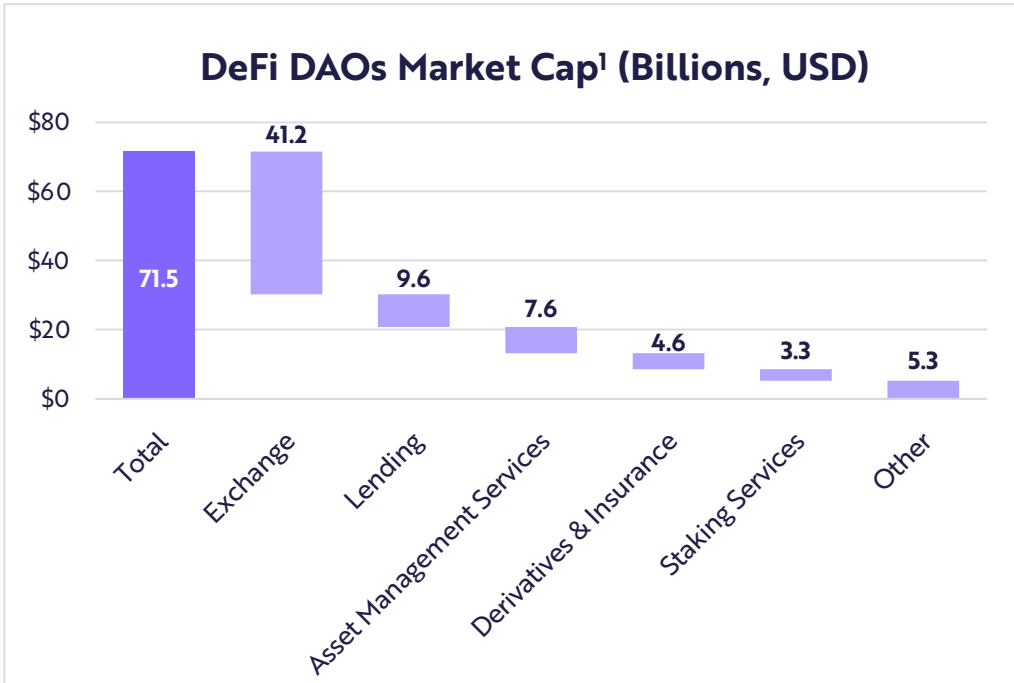
Note: DeFi application revenue is defined as Total Revenue by TokenTerminal (https://www.tokenterminal.com/terminal/metrics/revenue) – "How much are users paying to use a project's service? Revenue refers to the total fees paid by a blockchain's or decentralized application's end users and does not include Ethereum transaction fees. DeFi application employee count is defined as number of employees on the LinkedIn page for the founding entity (i.e., Compound Labs for Compound Protocol). TradFi Revenue and Employees is sourced from Ycharts and is based on standard quarterly financial statements. Representative companies
[1] LTM is defined as last twelve-month revenue. TradFi defined as Traditional Finance and representative of a traditional public company in the financial services industry. DeFi defined as Decentralized Finance, a categorization of software deployed on public blockchains focused on financial services functions.
Source: ARK Investment Management LLC, 2021 based on data sourced from: YCharts; TokenTerminal; LinkedIn

Decentralized Autonomous Organizations (DAOs) Enable A Novel Form Of Coordination And Governance

Critical to DeFi's governance, DAOs are replacing centralized, hierarchical corporate structures with decentralized communities.

	Traditional Corporations	DAOs
Ownership[3]	Permissioned	Permissionless
Governance	Costly	Frictionless
Accounting	Opaque	Transparent
Discourse	Private	Public



Example:

Uniswap DAO

- UNI token launched in September 2020
- 60% of genesis supply allocated to early community members
- ~$7.8 billion[2] in UNI token market cap
- ~296,000[4] unique addresses with UNI token[2]

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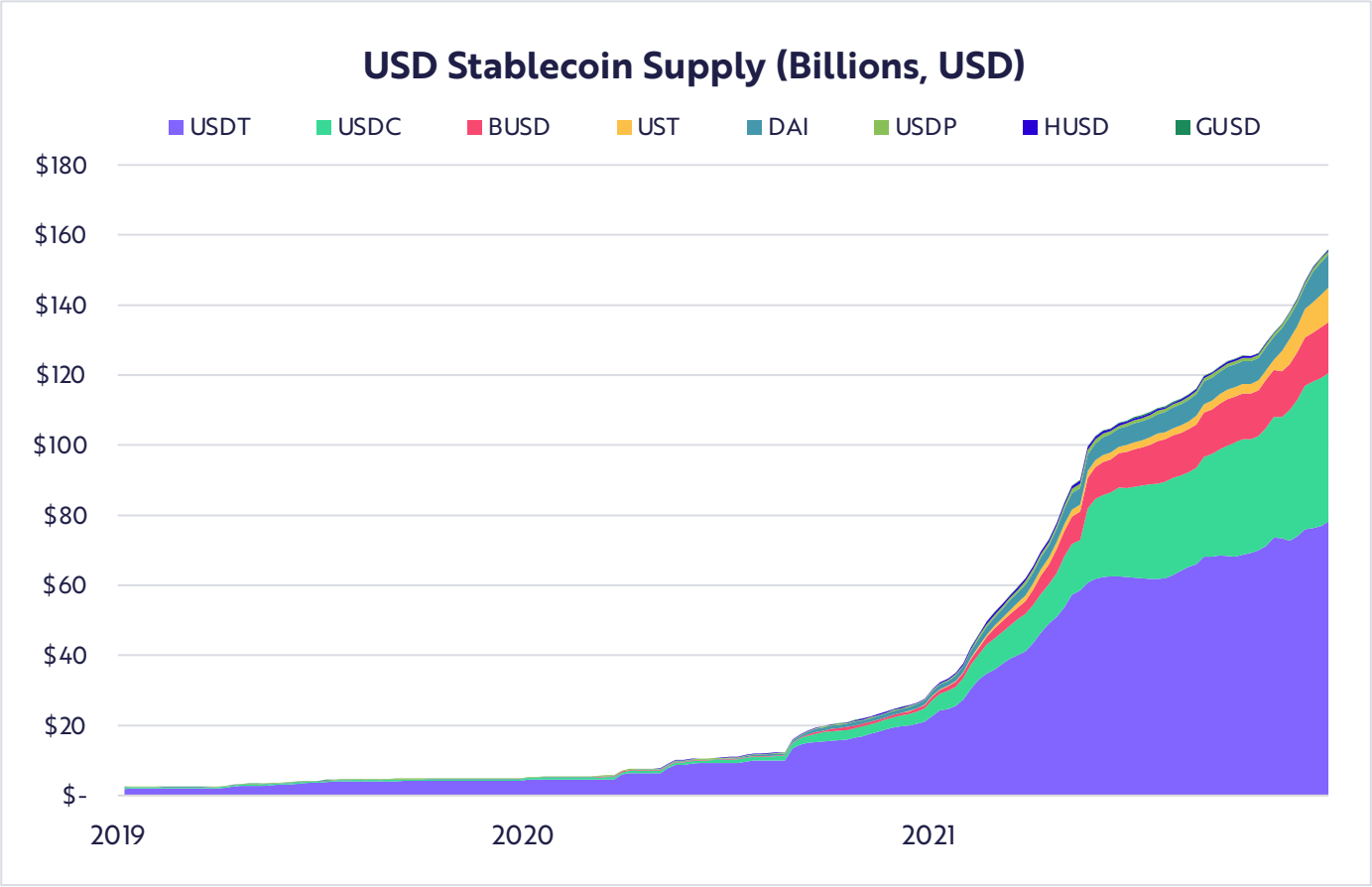
[1] As of January 4, 2022 | [2] CoinGecko market cap number as of December 31, 2021 | [3] Permissioned / Permissionless referring to the level of access rights required to obtain or assume ownership in a Traditional Corporation (private or public company) vs. a DAO. In Traditional Corporations, accredited investor status or access to a KYC'd US brokerage account is often necessary to become an owner, where as the barriers of entry to a DAO are much lower – often needing nothing more than an internet access to transact on the underlying blockchain network. [4] CoinMarketCap data
Note: Uniswap DAO was selected as a representative, "name brand" DAO for illustrative purposes
Source: ARK Investment Management LLC, 2021 based on data sourced from: DeFi Llama, Etherscan, CoinGecko, Uniswap

Stablecoins Have Fueled Crypto Trading, Lending, And Payments

Stablecoins—cryptoassets pegged to fiat currency, often the USD—serve as fixed-value assets for crypto trading, lending, and payments in both centralized and decentralized markets. They increased nearly 5x in 2021.

On international crypto exchanges with limited access to US Bank accounts, like Binance, stablecoin-denominated trading pairs account for more than 70% of total trading volume on centralized crypto exchanges, well above USD-denominated trading at only 15%.

Used heavily in DeFi, stablecoins account for 95% of total outstanding debt on Compound and 22% of total liquidity on Uniswap.



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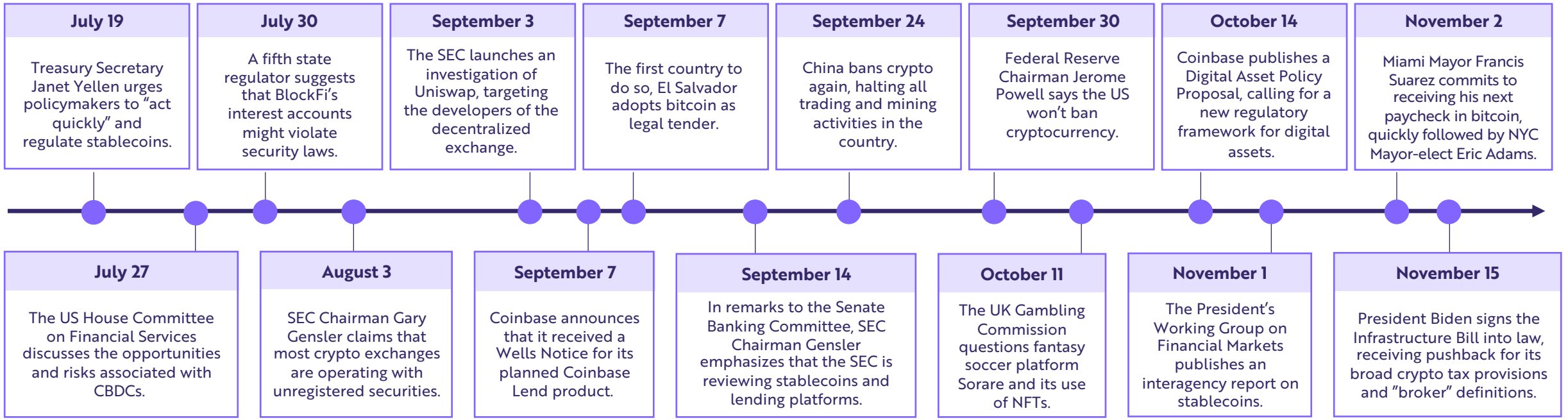
Source: ARK investment Management LLC, 2021 based on data sourced from: Glassnode, CoinMarketCap, The Block, DeFi Llama, Dune Analytics, Messari, Uniswap

Regulators Are Prioritizing Crypto Innovations, Especially DeFi



Source: ARK investment Management LLC, 2021 based on data sourced from: Banjo, Shelly, and Francesca Maglione. NYC Mayor-Elect Adams Says He'll Take Paycheck in Bitcoin. Bloomberg, 4 Nov. 2021, https://www.bloomberg.com/news/articles/2021-11-04/nyc-mayor-elect-eric-adams-says-he-ll-take-paycheck-in-bitcoin?sref=1f7Aj053. China's Top Regulators Ban Crypto Trading and Mining, Sending Bitcoin Tumbling. Reuters, 24 Sept. 2021, https://www.reuters.com/world/china/china-central-bank-vows-crackdown-cryptocurrency-trading-2021-09-24/, Coinbase. The SEC Has Told Us It Wants to Sue Us over Lend. We Don't Know Why. The Coinbase Blog, 8 Sept. 2021, https://blog.coinbase.com/the-sec-has-told-us-it-wants-to-sue-us-over-lend-we-have-no-idea-why-a3a1b6507009, Condon, Christopher. "Yellen Tells Regulators to 'Act Quickly' on Stablecoin Rules." Bloomberg.com, Bloomberg, 19 July 2021, https://www.bloomberg.com/news/articles/2021-07-19/yellen-tells-regulators-to-act-quickly-on-stablecoin-rules?sref=1f7Aj053, Crooks, Nathan. Miami's Mayor Says He'Ll Take His Next Paycheck in Bitcoin. Bloomberg, 2 Nov. 2021, https://www.bloomberg.com/news/articles/2021-11-02/miami-mayor-suarez-says-he-ll-take-next-paycheck-in-bitcoin-kvifidjb?sref=1f7Aj053. Digital Asset Policy Proposal: Safeguarding America's Financial Leadership. The Coinbase Blog, 14 Oct. 2021, https://blog.coinbase.com/digital-asset-policy-proposal-safeguarding-americas-financial-leadership-ce569c27d86c. Federal Reserve Chair Jerome Powell: U.S. Has No Plans to Ban Bitcoin and Crypto. Nasdaq, 30 Sept. 2021, https://www.nasdaq.com/articles/federal-reserve-chair-jerome-powell%3A-u.s.-has-no-plans-to-ban-bitcoin-and-crypto-2021-09. Hayward, Andrew. Ethereum NFT Game Sorare Investigated by UK Gambling Commission. Decrypt, 11 Oct. 2021, https://decrypt.co/83194/ethereum-nft-game-sorare-investigated-uk-gambling. Michaels, Dave, and Alexander Osipovich. Regulators Investigate Crypto-Exchange Developer Uniswap Labs. The Wall Street Journal, 3 Sept. 2021, https://www.wsj.com/articles/regulators-investigate-crypto-exchange-developer-uniswap-labs-11630666800?mod=latest_headlines. Post, Kollen. Biden Signs Infrastructure Bill, Handing Crypto Broker Definitions to the US Treasury. The Block, 15 Nov. 2021, https://www.theblockcrypto.com/linked/124387/biden-signs-infrastructure-bill-handing-crypto-broker-definitions-to-the-us-treasury. Post, Kollen. "Kentucky Is Fifth State to Scrutinize Blockfi's Interest Accounts." The Block, The Block, 30 July 2021, https://www.theblockcrypto.com/linked/113124/kentucky-regulator-blockfi-interest-security. President's Working Group on Financial Markets Releases Report and Recommendations on Stablecoins. U.S. Department of the Treasury, 1 Nov. 2021, https://home.treasury.gov/news/press-releases/jy0454. The Promises and Perils of Central Bank Digital Currencies. U.S. House Committee on Financial Services, 27 July 2021, https://financialservices.house.gov/events/eventsingle.aspx?EventID=408111. Remarks Before the Aspen Security Forum. U.S. Securities and Exchange Commission, 3 Aug. 2021, https://www.sec.gov/news/public-statement/gensler-aspen-security-forum-2021-08-03. Sinclair, Sebastian. Bitcoin Now Legal Tender in El Salvador, Marking World First. CoinDesk, 7 Sept. 2021, https://www.coindesk.com/policy/2021/09/07/bitcoin-now-legal-tender-in-el-salvador-marking-world-first/. Testimony Before the United States Senate Committee on Banking, Housing, and Urban Affairs. U.S. Securities and Exchange Commission, 14 Sept. 2021, https://www.sec.gov/news/testimony/gensler-2021-09-14.

Ethereum Is A Work In Progress

ETH 2.0 Claim*		Considerations
More scalable	Sharding and layer 2 scaling solutions will expand Ethereum's throughput from 15 to 100,000 transactions per second.	• Layer 2 scaling solutions took off more slowly than expected, hindered by long withdrawal times and limited layer 2 liquidity. • Managing shards and multiple layer 2s will be a challenge for developers.
More secure	Proof of Stake (PoS) consensus will increase both decentralization and the cost of attacking the network.	• Putting control in the hands of the wealthiest token holders and limited physical barriers to entry, increase the risk of centralization. • Existing Proof of Stake chains have not been shown to be more decentralized than Proof of Work.
More sustainable	Proof of Stake (PoS) consensus is a "greener" alternative to Proof of Work (PoW).	• Proof of Work mining could accelerate the world's transition to renewable energy. • Energy consumed does not mean energy wasted.

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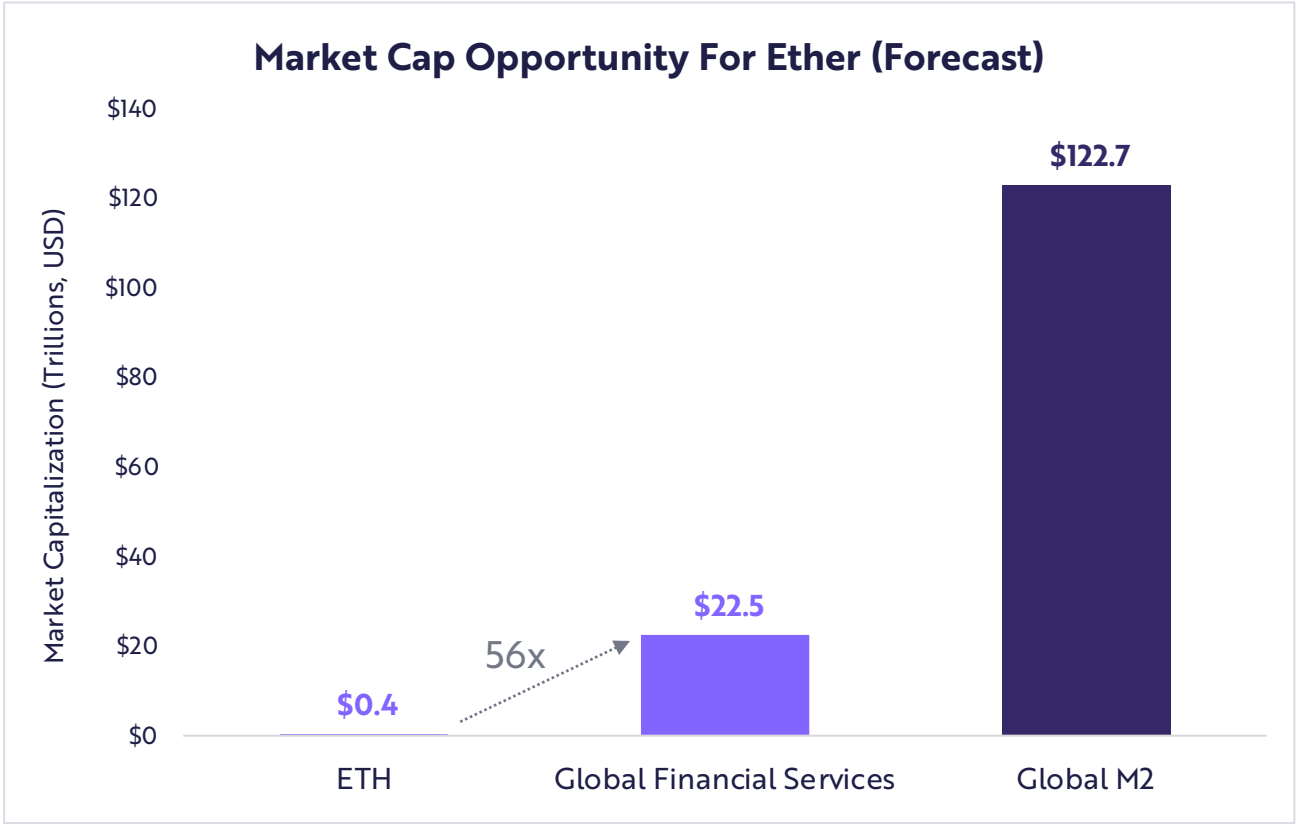
Source: ARK Investment Management LLC, 2021 based on data sourced from: "The Beacon Chain." Ethereum.org, 31 July 2021, https://ethereum.org/en/eth2/beacon-chain/; Buterin, Vitalik. "Ethereum Whitepaper." Ethereum.org, 2013, https://ethereum.org/en/whitepaper/; Caffyn, Grace. "Ethereum Launches Long-Awaited Decentralized App Network." CoinDesk Latest Headlines RSS, CoinDesk, 30 July 2015, https://www.coindesk.com/markets/2015/07/30/ethereum-launches-long-awaited-decentralized-app-network/; Ethereum Foundation. Eth2.0 Implementers Call #19 [2019/6/13]. 13 June 2019, https://www.youtube.com/watch?v=izspfej05lE&t=2640s; Fadilpašić, Sead. "Ethereum Merge Estimated in May-June 2022 - Developers." Crypto News, 18 Oct. 2021, https://cryptonews.com/news/ethereum-merge-estimated-in-may-june-2022-developers.htm; Vitalik.eth. "2. Ethereum Proof of Stake Research Began in Jan 2014 with Slasher..." Twitter, Twitter, 16 Aug. 2018, https://twitter.com/VitalikButerin/status/1029900794353483776.

Ether's Market Cap Could Exceed $20 Trillion In The Next 10 Years

According to our research, Ethereum could displace many traditional financial services, and its native token, ether, could compete as global money.

As financial services move on-chain, decentralized networks are likely to take share from existing financial intermediaries. The beneficiaries of this shift include Ethereum, the base protocol, and DeFi, the decentralized applications built on top of Ethereum.

As the preferred collateral in DeFi and the unit of account in NFT marketplaces, ether (ETH) has the potential to capture a portion of the $123 trillion in global M2.



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Source: ARK Investment Management LLC, 2021 based on data sourced from: "Broad Money (% of GDP)." The World Bank, https://data.worldbank.org/indicator/FM.LBL.BMNY.GD.ZS; "GDP (Current US$)." The World Bank, https://data.worldbank.org/indicator/NY.GDP.MKTP.CD; "Global Financial Services Market Outlook 2021-2030; Expected to Reach $28.52 Trillion by 2025 - Researchandmarkets.com." Business Wire, 10 Mar. 2021, https://www.businesswire.com/news/home/20210310005386/en/Global-Financial-Services-Market-Outlook-2021-2030-Expected-to-Reach-28.52-Trillion-by-2025---ResearchAndMarkets.com.

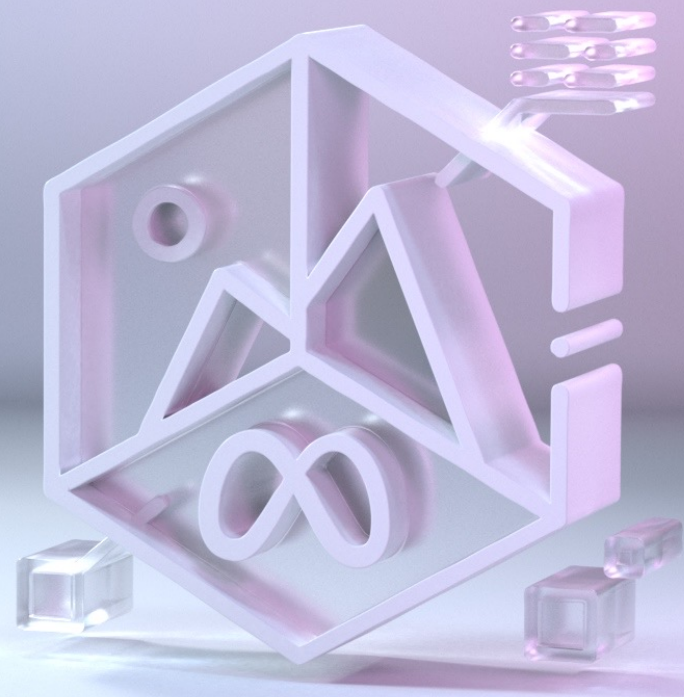
ARK • BIG IDEAS 2022

ARK INVEST

Web3

An Internet Revolution

Research by Nicholas Grous, Frank Downing, ARK Analysts, and Andrew Kim, ARK Analyst Intern



Now that consumers are spending more time and resources online, the importance of digital assets is likely to increase considerably as consumer spending shifts to virtual worlds. A global framework like non-fungible tokens (NFTs) provides a stable way of taking the ownership and control of digital assets away from corporations, to the benefit of individuals.

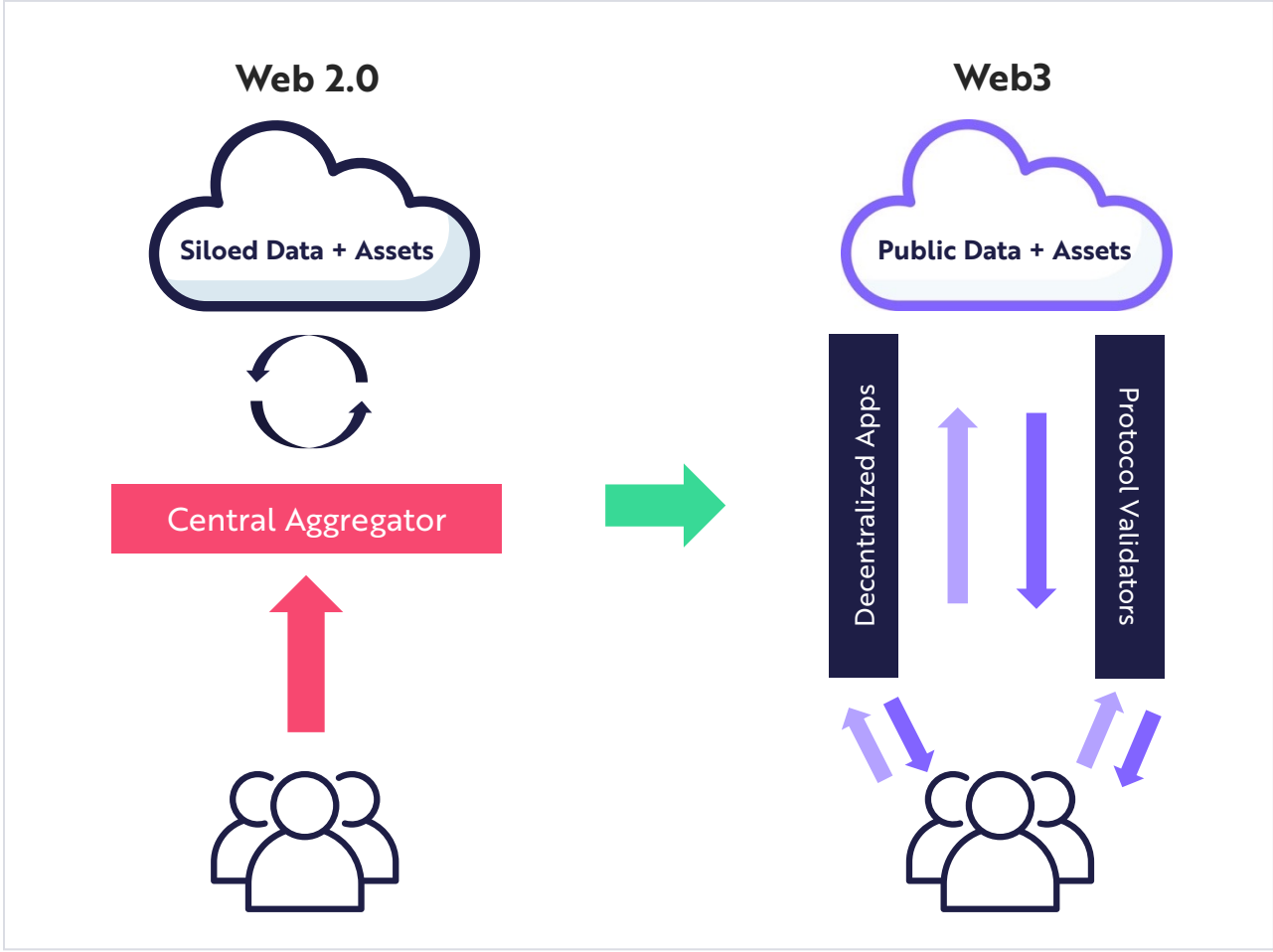
By 2030, we expect Web3 to depress annual offline consumption by $7.3 trillion, boosting direct online expenditures at an annual rate of 28%, from $1.4 trillion today to $12.5 trillion per year.

Digital Ownership Could Accelerate The Transition Of Activity From The Physical To The Digital World

We believe Web3 virtual ecosystems will thrive if online human participants can own—as opposed to use or rent—digital assets.

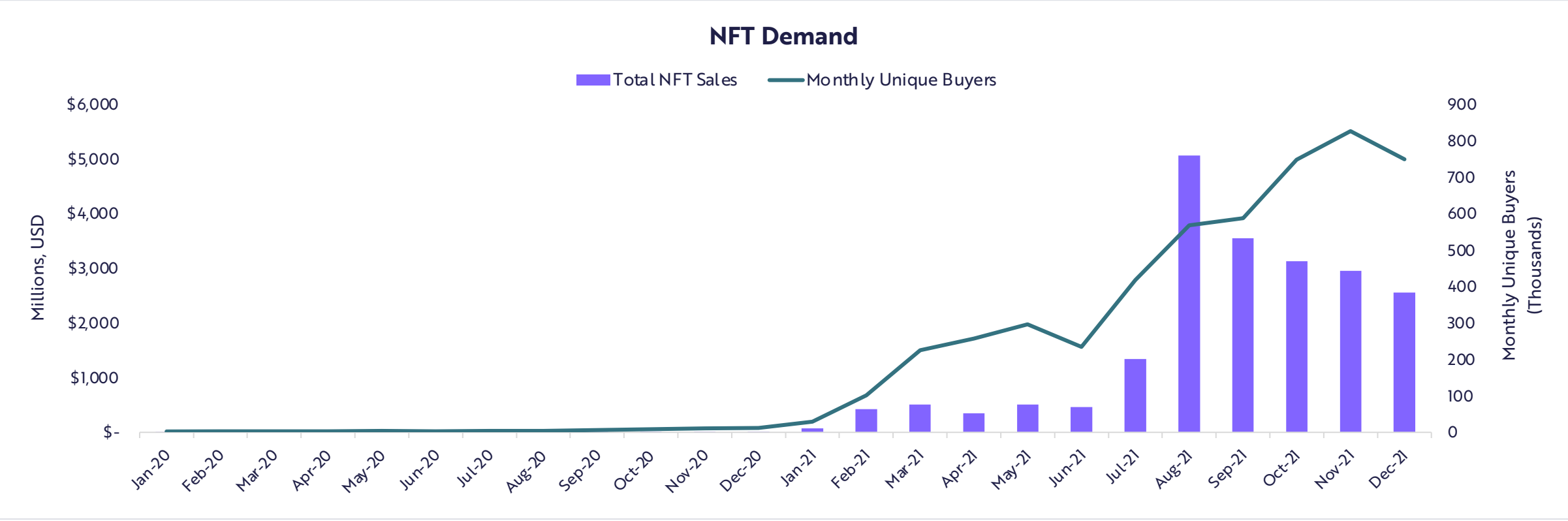
In traditional Web 2.0 business models, end users typically face restrictions on products or services. They cannot port in-game assets from one game to another, for example, and they risk censorship on the social media platforms that profit from their content.

In contrast, public and decentralized blockchains allow users to store and trade their assets in a legitimate secondary market.



Public Blockchains Enable The Ownership Of Digital Assets

Non-fungible tokens (NFTs) serve as smart contracts that verify the ownership of digital assets on public blockchains. They usurp the power of centralized platforms to house, control, and verify assets. In 2021, NFTs generated $21 billion in sales as the number of monthly unique buyers soared nearly eight-fold to more than 700,000.



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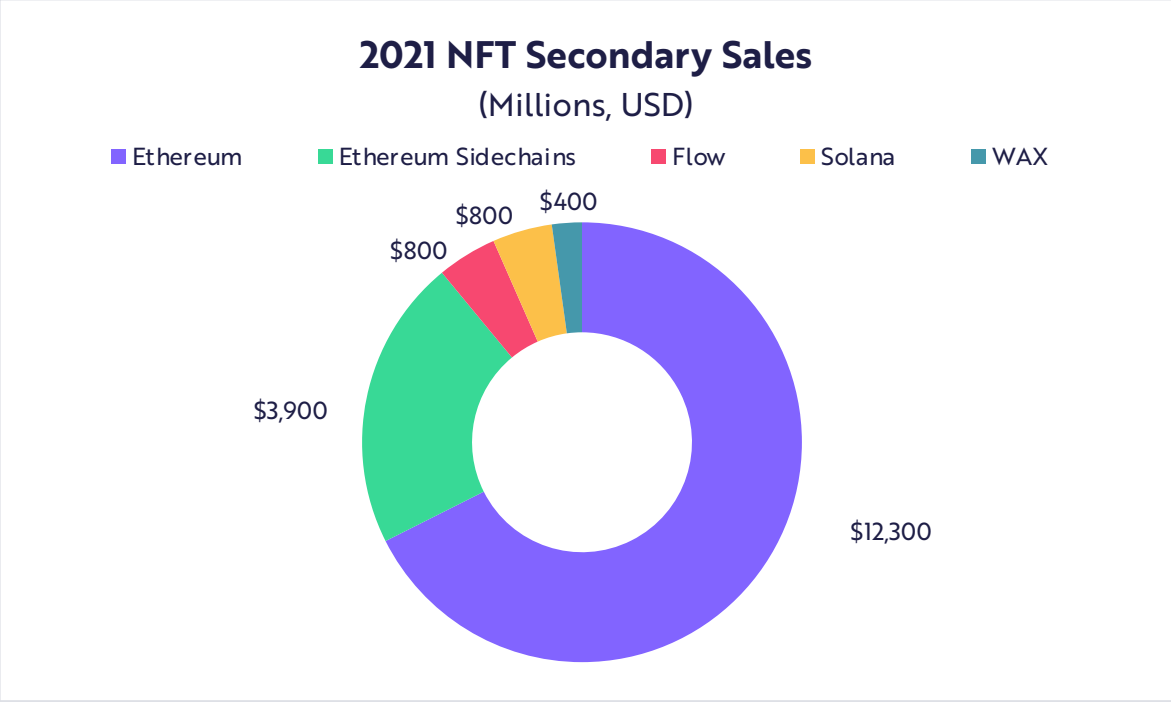
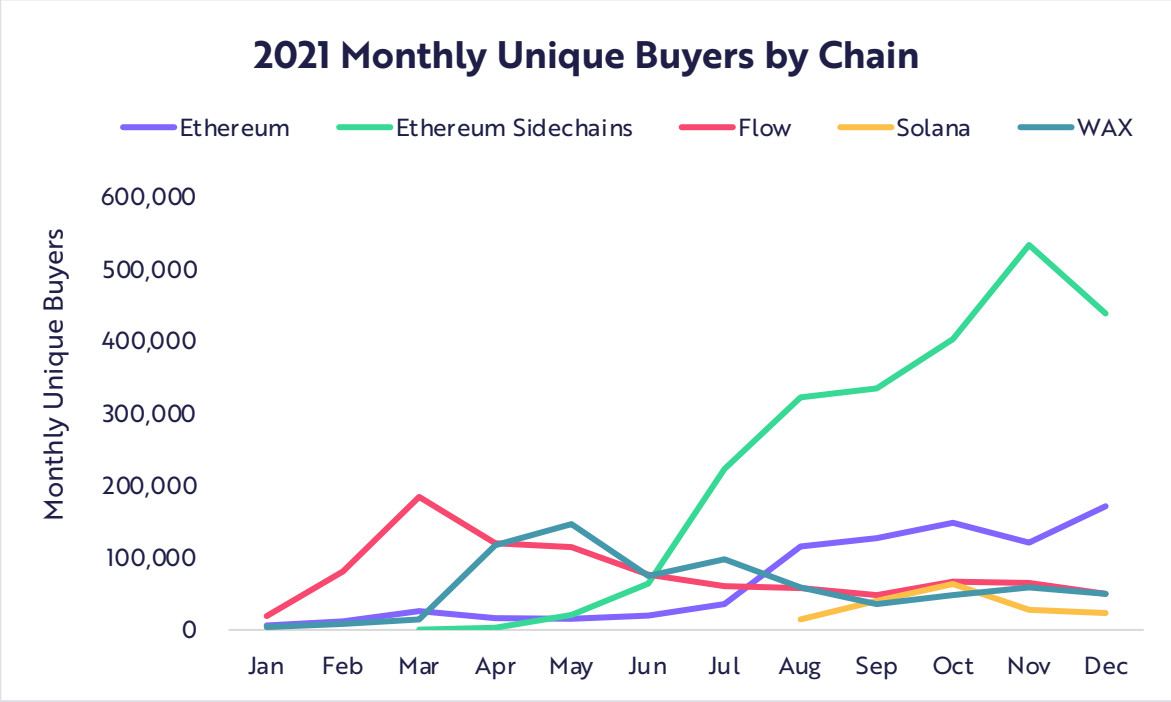
Source: ARK Investment Management LLC, data sourced from Cryptoslam and NonFungible.

Ethereum Has Been The Chain Of Choice For Smart Contracts Thus Far

Based on public data, Ethereum is the dominant smart contract platform and the blockchain of choice for NFT issuance and transactions. As fees continue to rise on Ethereum, however, the competition from other layer-1 blockchains and layer-2 scaling technologies is likely to increase.





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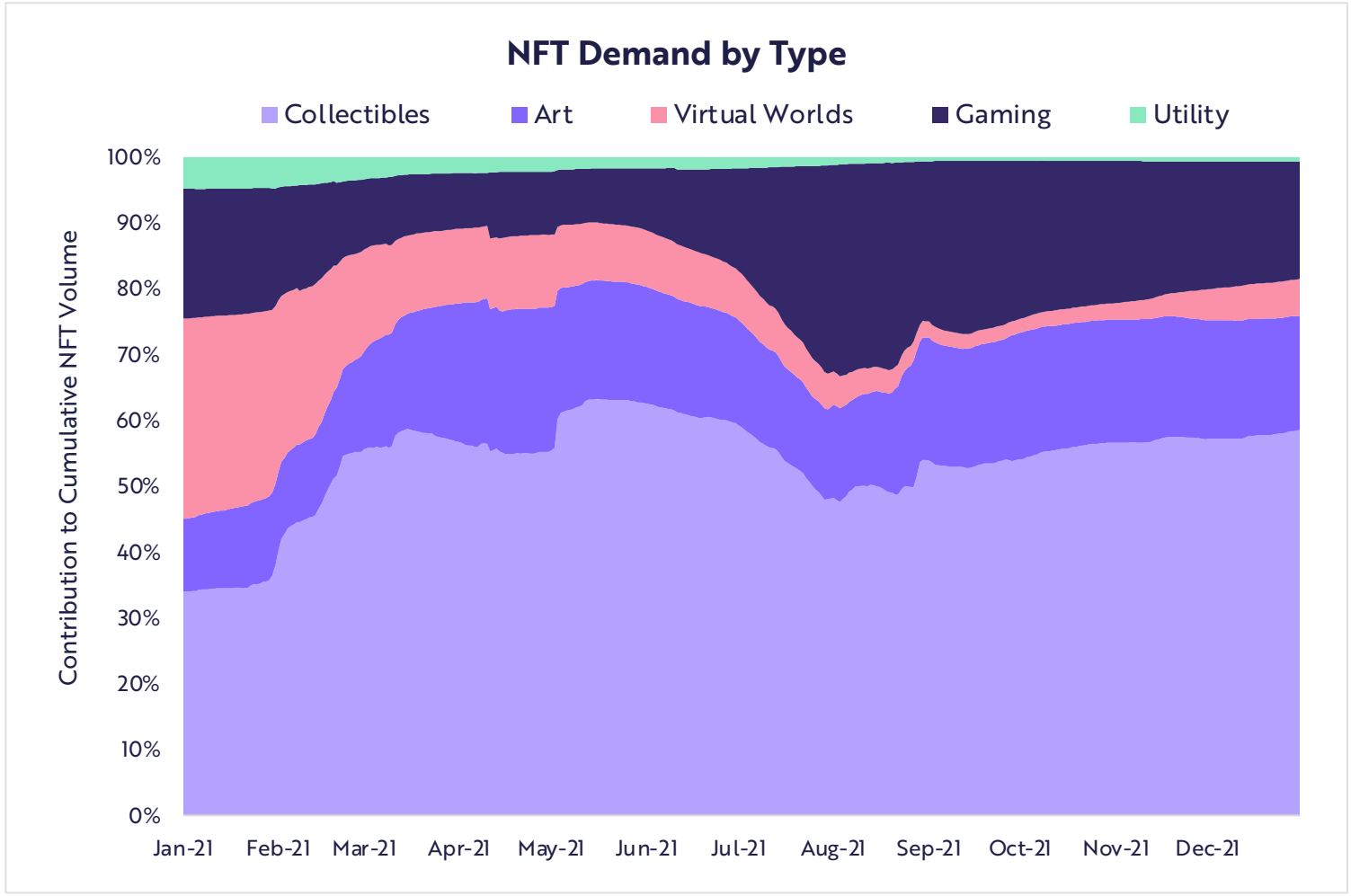
We refer to layer-1 as the underlying blockchain architecture for any smart contract platform. As usage grows on Ethereum's underlying blockchain, demand for space on each block grows while the size of the blocks remains the same, causing, on average, higher fees for participants. To mitigate the negative impact of higher demand for Ethereum, various developer teams are innovating with different scaling solutions to increase the rate of transactions processed, also known as throughput. We refer to Ethereum sidechains as separate blockchains from Ethereum with their own set of consensus mechanisms that are compatible with Ethereum. We only include the sum of Ronin and Polygon as Ethereum Sidechains within the charts. Layer-2 solutions build protocols on top of Ethereum itself to handle large batches of transactions off-chain rather than on a separate blockchain as sidechains do. Cumulative NFT secondary sales volume is rounded to the nearest hundred million US dollars.
Source: ARK Investment Management LLC, 2021, data sourced from Cryptoslam.

NFTs Could Shift From Static Collectibles to Dynamic Digital Assets

Currently, collectibles and digital art account for more than 75% of NFT sales on Ethereum.

NFT sales in virtual worlds like The Sandbox and games like Axie Infinity have accounted for less than 25% of cumulative sales on Ethereum.

Based on the evolution of the video gaming market, NFT demand for blockchain-based games and virtual worlds could exceed that for digital collectibles and art, especially as collectibles and art begin to exhibit more utility in various games during the next five to ten years.



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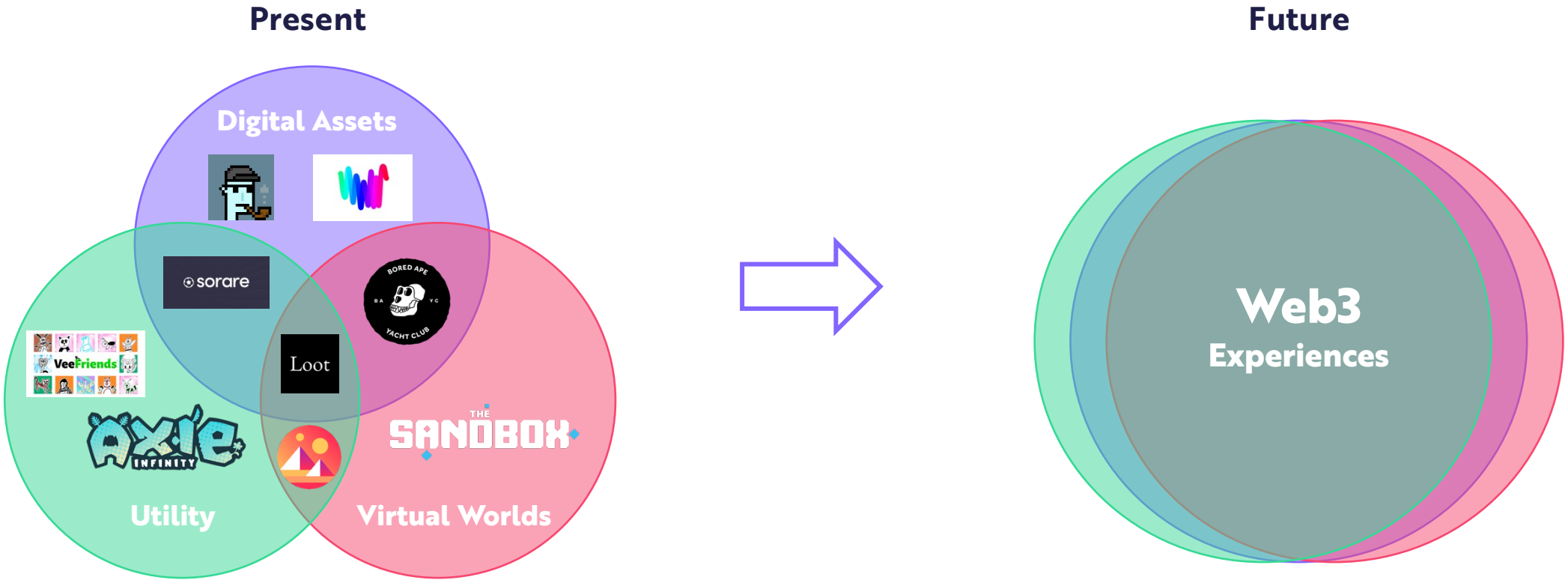
Source: ARK Investment Management LLC, data sourced from NonFungible.

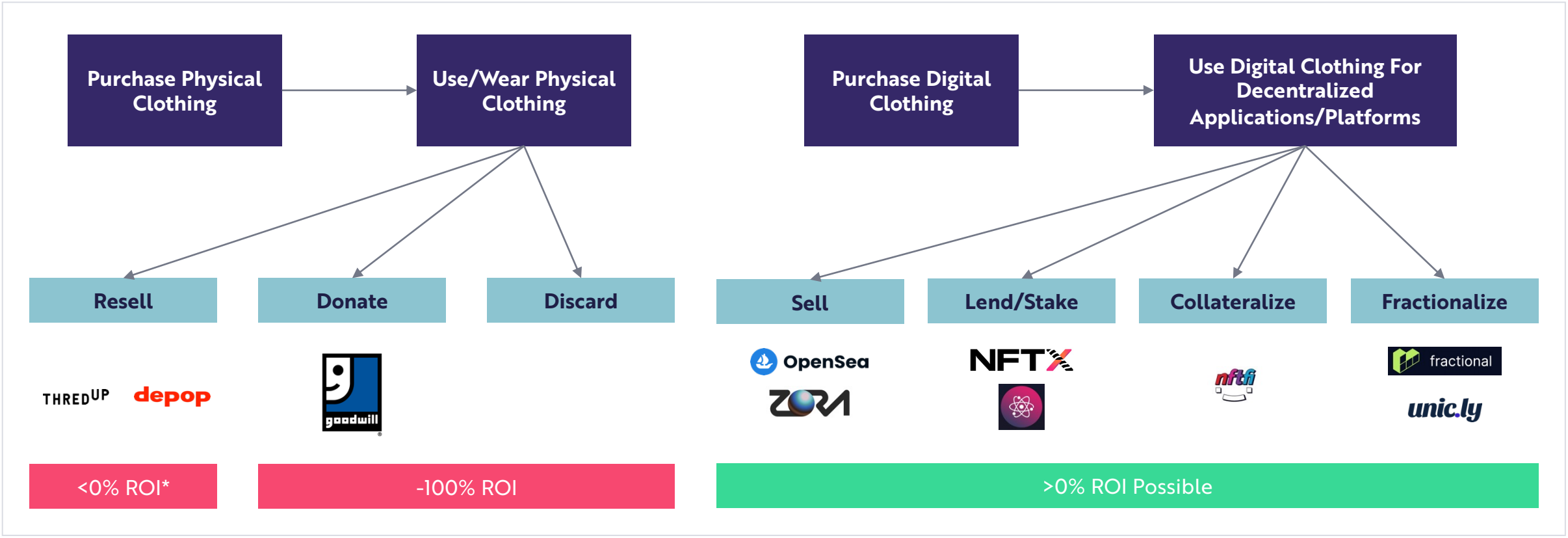
Dynamic NFTs Create A New Type of Active Entertainment

The increasing interoperability of NFTs could enable the convergence of collecting, gaming, socializing, and investing.



We Believe NFTs Will Blur The Line Between Consumption And Investment

NFTs offer a liquid marketplace in which consumers can invest in different digital assets and engage in peer-to-peer transactions. NFT buyers and sellers determine market-clearing prices on blockchains instead of data aggregation platforms, creating new forms of asset monetization.



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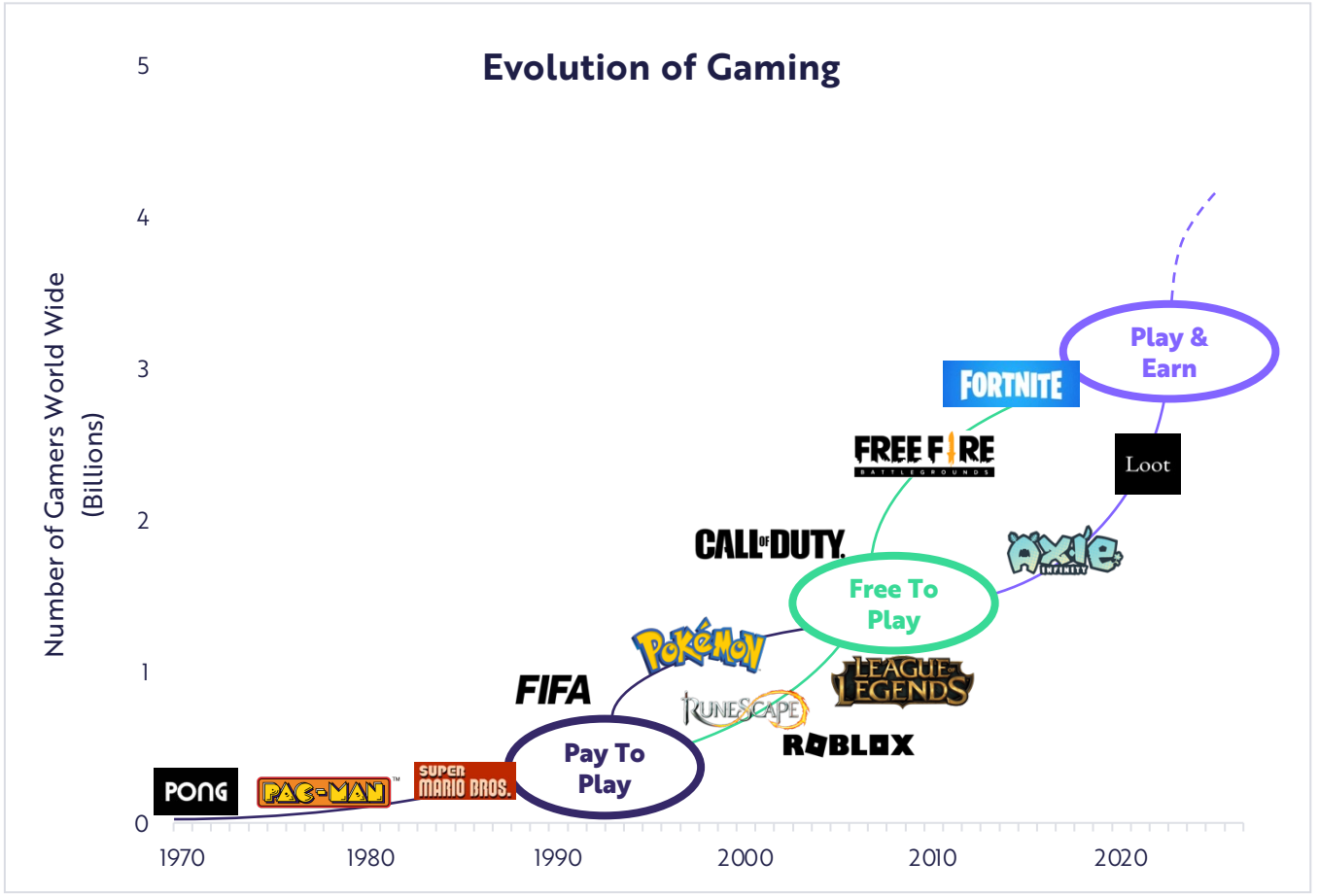
*We believe that the negative return on investment (ROI) on secondary transactions of physical clothing is most applicable to non-luxury goods that are not assigned a premium for rarity.
Source: ARK Investment Management LLC., 2021 | Note: Each entity presented above is a representative sample of a "name brand" in their respective verticals.

Blockchain-Based Gaming Can Enable Entertainment And Monetization Simultaneously

Pay-to-Play models require end-users to purchase games at a fixed cost.

Free-to-Play models are replacing Pay-to-Play and unlocking a larger customer base. Virtual goods and gaming-as-a-service are increasing the revenue upside for game developers.

Because NFTs recognize the ownership of in-game assets, they are enabling **Play-and-Earn** models. Games can raise capital and reward users through NFT sales and in-game rewards.



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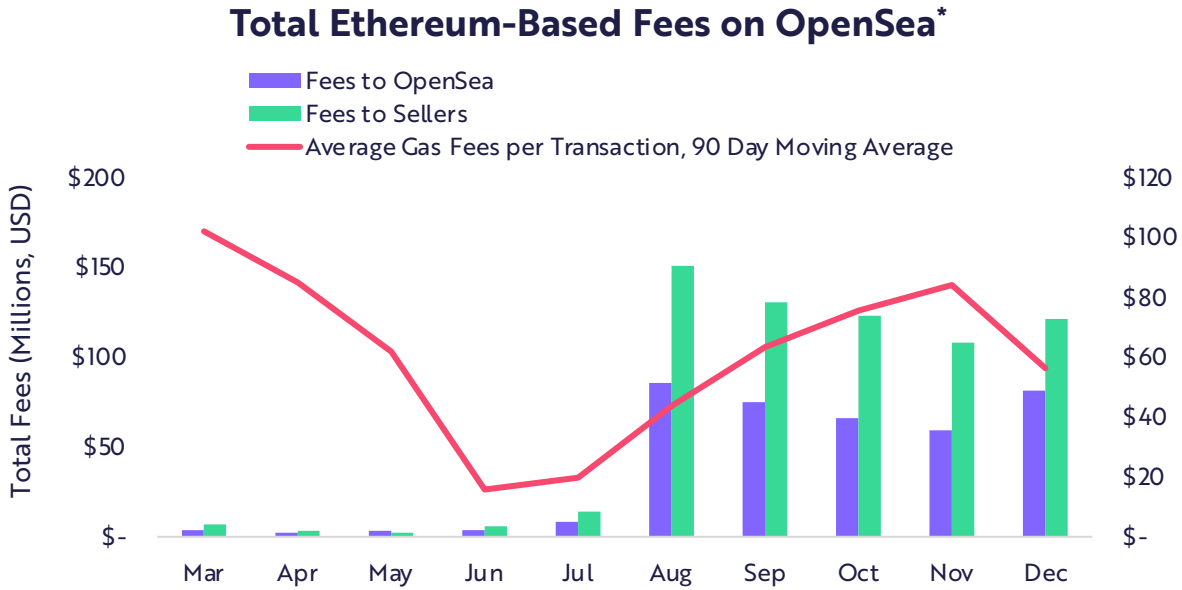
Source: ARK Investment Management LLC, 2021, data sourced from DFC Intelligence and Sport Hiatus for historical data points for years 2014 onwards.

NFT Projects Can Maximize The Returns To Individual Buyers And Sellers

Compared to centralized platforms like Amazon, NFT aggregators like OpenSea charge a fraction of their transaction take rates. As demand for blockchain-based assets grows, however, the cost to use the blockchain—as measured by gas fees—grows. Various scaling solutions are in development to help lower the cost of using these blockchains.

Platform	Take Rate	Protocol-Level Cost per Transaction
Sotheby's	13.9% - 25.0%	$0
Amazon	8.0% - 15.0%	$0
eBay	10.0%	$0
Etsy	5.0%	$0
OpenSea	2.5%	$65*
Immutable X	2.0%	≈ $0



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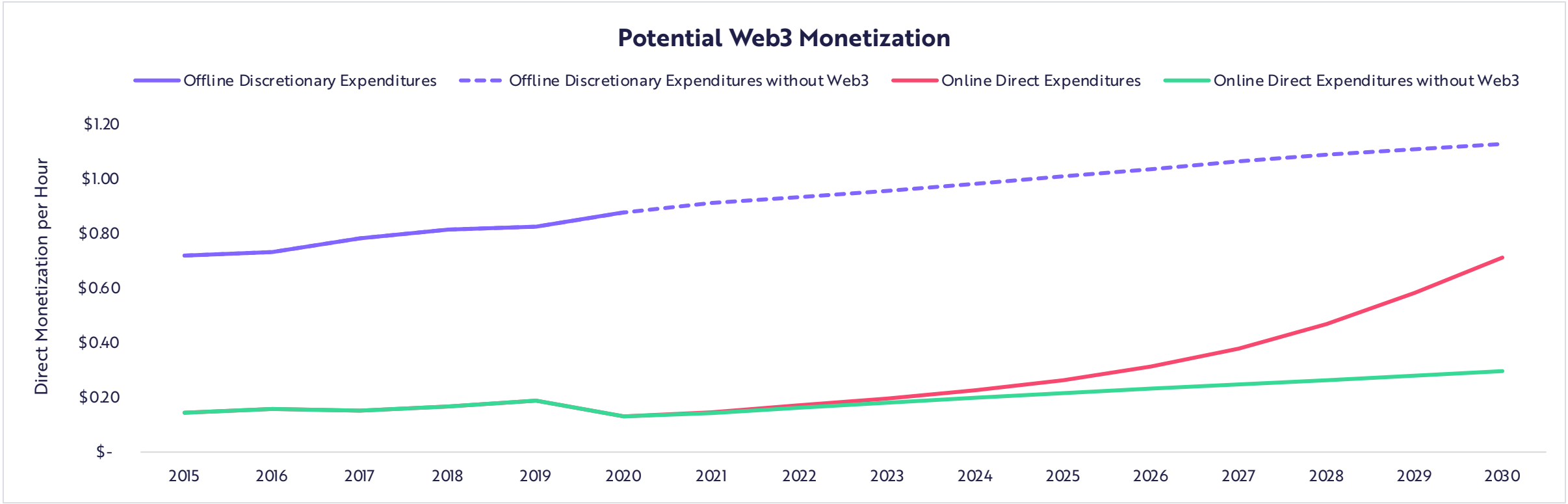
Gas fees are payments made by users to compensate for the computing energy required to process and validate transactions on the Ethereum blockchain. Immutable X's take rate does not include the default application fee paid out to application developers and only includes the fees accrued to Immutable.
*OpenSea's decentralization cost per transaction is calculated using the annual average of the daily average transaction fees used by OpenSea's contract for a single transaction. The 90-day moving average gas fees per transaction use the same underlying data used to compute OpenSea's decentralization cost.
Source: ARK Investment Management LLC, 2021, data sourced from Amazon, Dune Analytics, eBay, Etsy, Immutable X, OpenSea, and Sotheby's.

If Web3 Proliferates, The Monetization Rate Of Online Spending Should Approach That Of Offline Spending By 2030

Our research suggests that the monetization of time spent online will grow at a compound annual rate of 19% with Web3 but only 8% without Web3 during the next ten years.



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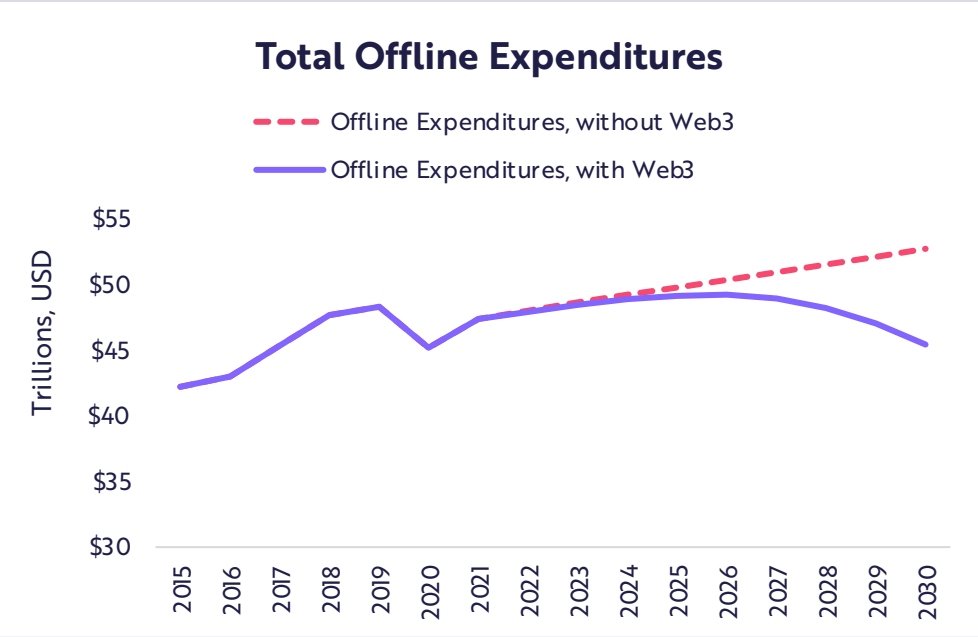
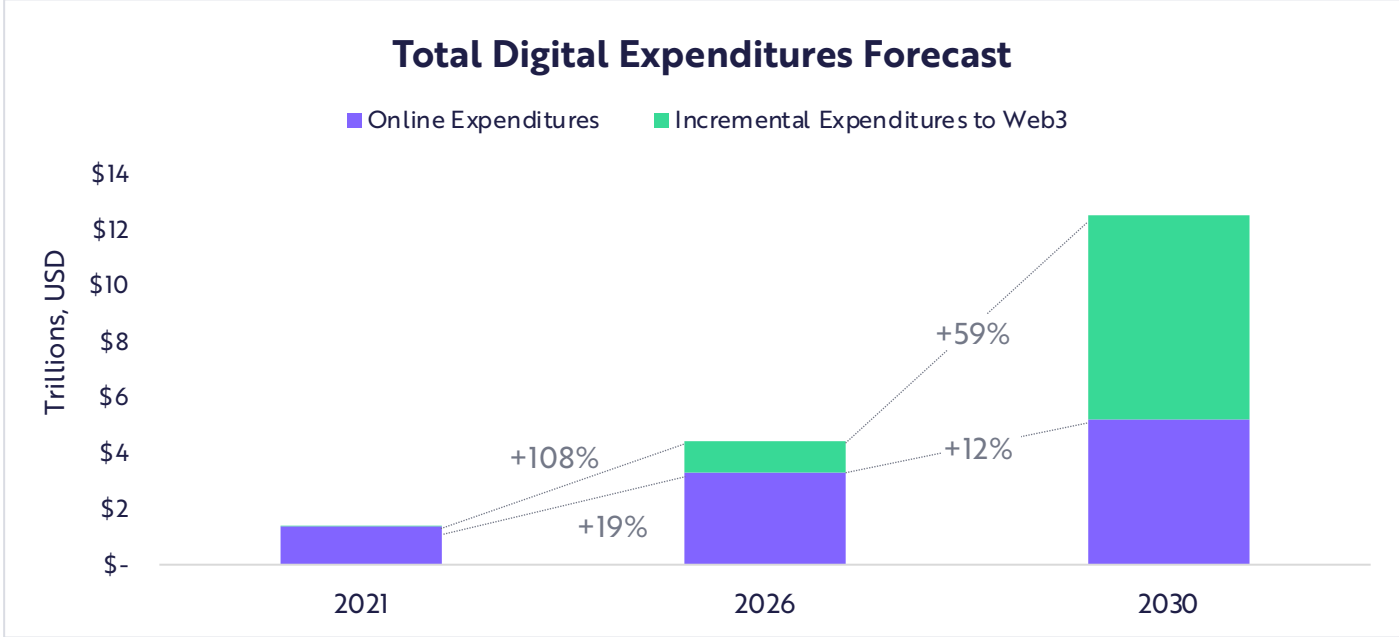
Source: ARK Investment Management LLC, data sourced from Bond Capital, CEIC Holdings, China Internet Watch, Cryptoslam, Digital Commerce 360, Dune Analytics, eMarketer, EuroCommerce, Federal Reserve Economic Data, FTI Consulting, Invesp, National Bureau of Statistics of China, Newzoo, NonFungible, NPD Group, Statista, United States Bureau of Labor Services, United States Census Bureau, United States Department of Labor, and World Bank Group.

Thanks To Web3, Annual Online Expenditures Could Reach $12.5 Trillion In The Next Decade

Based on ARK's research, offline consumption will peak mid decade at $49 trillion annually and then decline in response to Web3 . Without Web3 , annual online expenditures is likely to grow at an annual rate of 16%, from $1.4 trillion in 2021 to $5.2 trillion in 2030. With Web3 , annual online expenditures are likely to grow at an annual rate of 28% to $12.5 trillion.





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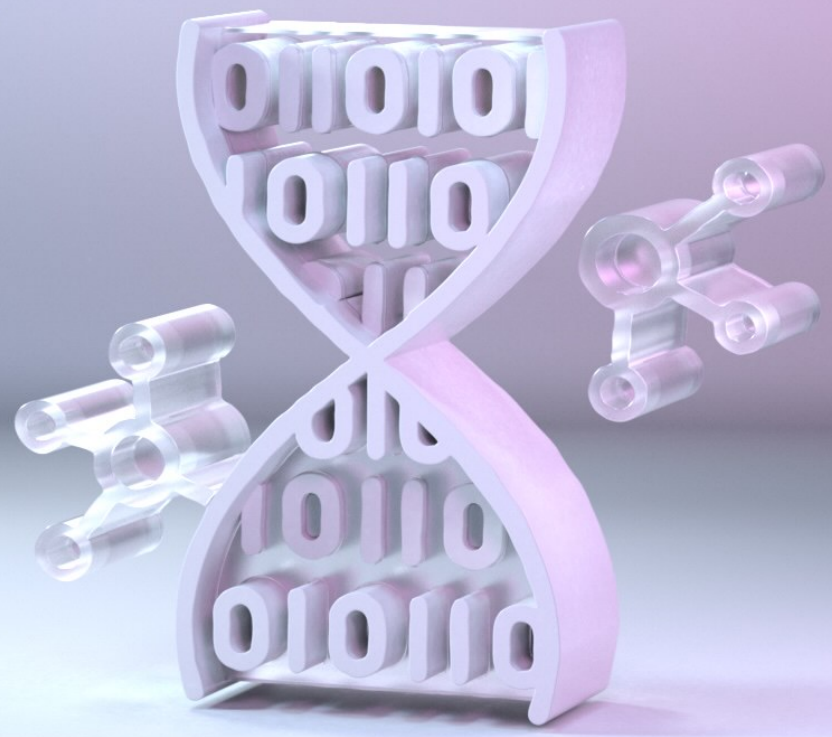
Source: ARK Investment Management LLC, 2021, data sourced from Bond Capital, CEIC Holdings, China Internet Watch, Cryptoslam, Digital Commerce 360, Dune Analytics, eMarketer, EuroCommerce, Federal Reserve Economic Data, FTI Consulting, Invesp, National Bureau of Statistics of China, Newzoo, NonFungible, NPD Group, Statista, United States Bureau of Labor Services, United States Census Bureau, United States Department of Labor, and World Bank Group.

ARK INVEST

Gene Editing

Curing Disease, Not Masking Symptoms

Research by Ali Urman, ARK Analyst



The convergence of next generation DNA sequencing, CRISPR gene-editing, and artificial intelligence (AI) has the potential to transform health care. These advances could accelerate the pace of scientific discovery, personalizing medicine to cure disease instead of masking symptoms.

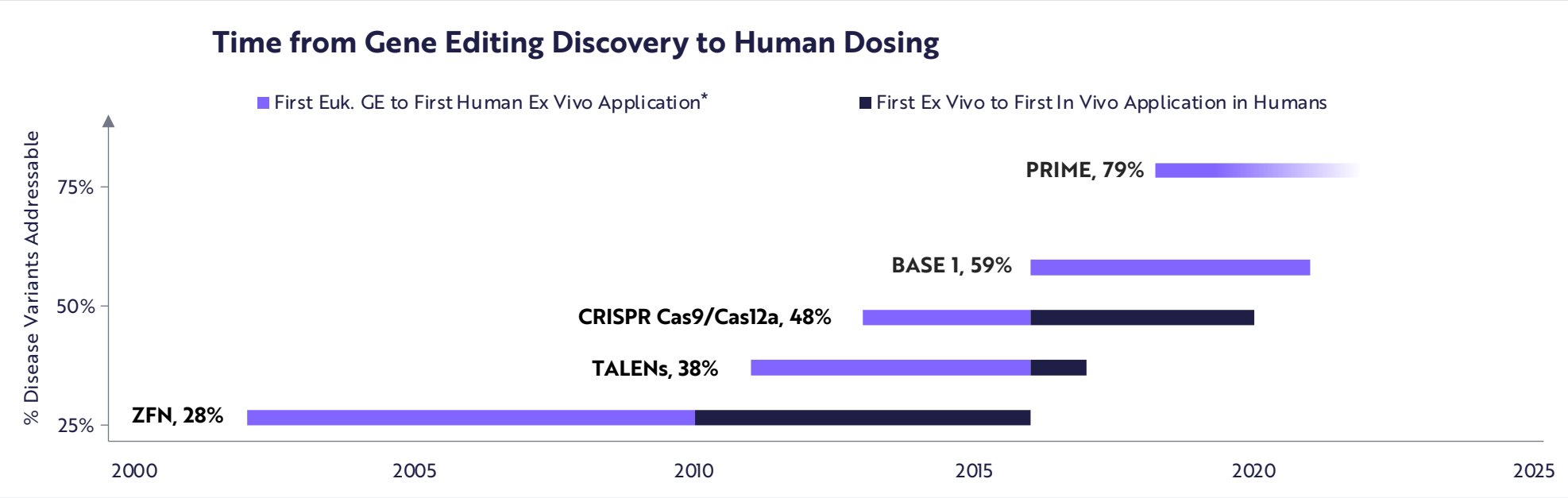
Based on ARK's research, the equity market capitalization of gene editing and gene therapy companies could grow 54% at a compound annual rate of return, scaling from roughly $130 billion today to $1.1 trillion by 2026.

The Pace Of Gene Editing Innovation Is Accelerating

According to our research, gene editing breakthroughs are creating more effective therapies at a faster rate than historically has been the case. Compared to Zinc Finger nucleases (ZFNs), which moved from discovery to the first human dose in roughly eight years, CRISPR took less than half the time, three years, and can address 48% of known diseases, nearly twice ZFNs' 28%. Prime and Base editing, CRISPR derivatives, address even more diseases, 79% and 59% respectively.

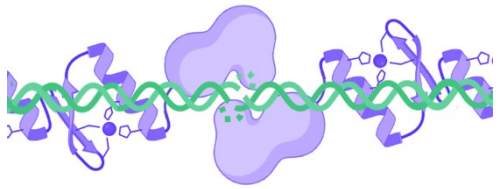
Note:
Ex vivo modifies a patient's cells outside the body and then transplants them back into the patient.

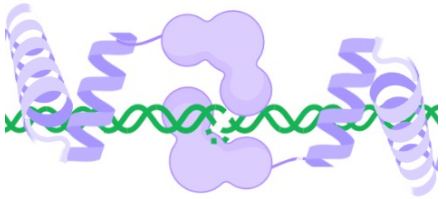
In vivo gene therapy modifies a patient's cells inside the body.

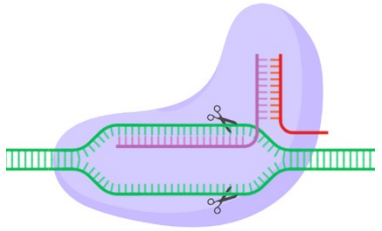


*Euk GE, or Eukarys Gene Editing, refers to the first successful gene edit on a non-human eukaryotic cell using the specific gene editing method. | Forecasts are inherently limited and cannot be relied upon. | For informational purposes only and should not be considered investment advice, or a recommendation to buy, sell or hold any particular security. Source: Orphanet: an online database of rare diseases and orphan drugs. Copyright, INSERM 1997. Available at http://www.orpha.net Accessed (12/10/2021). P. A. Jamieson, Addressable Variants Analysis Tool, (2021), GitHub repository,https://github.com/jamiesonpa/addressable_variants_gene_editing; Bibikova M, Golic M, Golic KG, Carroll D. Targeted chromosomal cleavage and mutagenesis in Drosophila using zinc-finger nucleases. Genetics. 2002 Jul;161(3):1169-75. doi: 10.1093/genetics/161.3.1169. PMID: 12136019; PMCID: PMC1462166. Sander, J., Cade, L., Khayter, C. et al. Targeted gene disruption in somatic zebrafish cells using engineered TALENs. Nat Biotechnol 29, 697–698 (2011). https://doi.org/10.1038/nbt.1934. Liu, X., Zhang, Y., Cheng, C. et al. CRISPR-Cas9-mediated multiplex gene editing in CAR-T cells. Cell Res 27, 154–157 (2017). https://doi.org/10.1038/cr.2016.142 CRISPR-Cas9-mediated multiplex gene editing in CAR-T cells Cell Research - CRISPR-Cas9-mediated multiplex gene editing in CAR-T cells. Su, S., Hu, B., Shao, J. et al. CRISPR-Cas9 mediated efficient PD-1 disruption on human primary T cells from cancer patients. Sci Rep 6, 20070 (2016). https://doi.org/10.1038/srep20070. National Library of Medicine (U.S.). (https://clinicaltrials.gov/ct2/show/NCT02702115; National Library of Medicine (U.S.). (https://clinicaltrials.gov/ct2/show/NCT03226470; National Library of Medicine (U.S.). (https://clinicaltrials.gov/ct2/show/NCT04601051

CRISPR Appears To Be the Superior Gene Editing Method





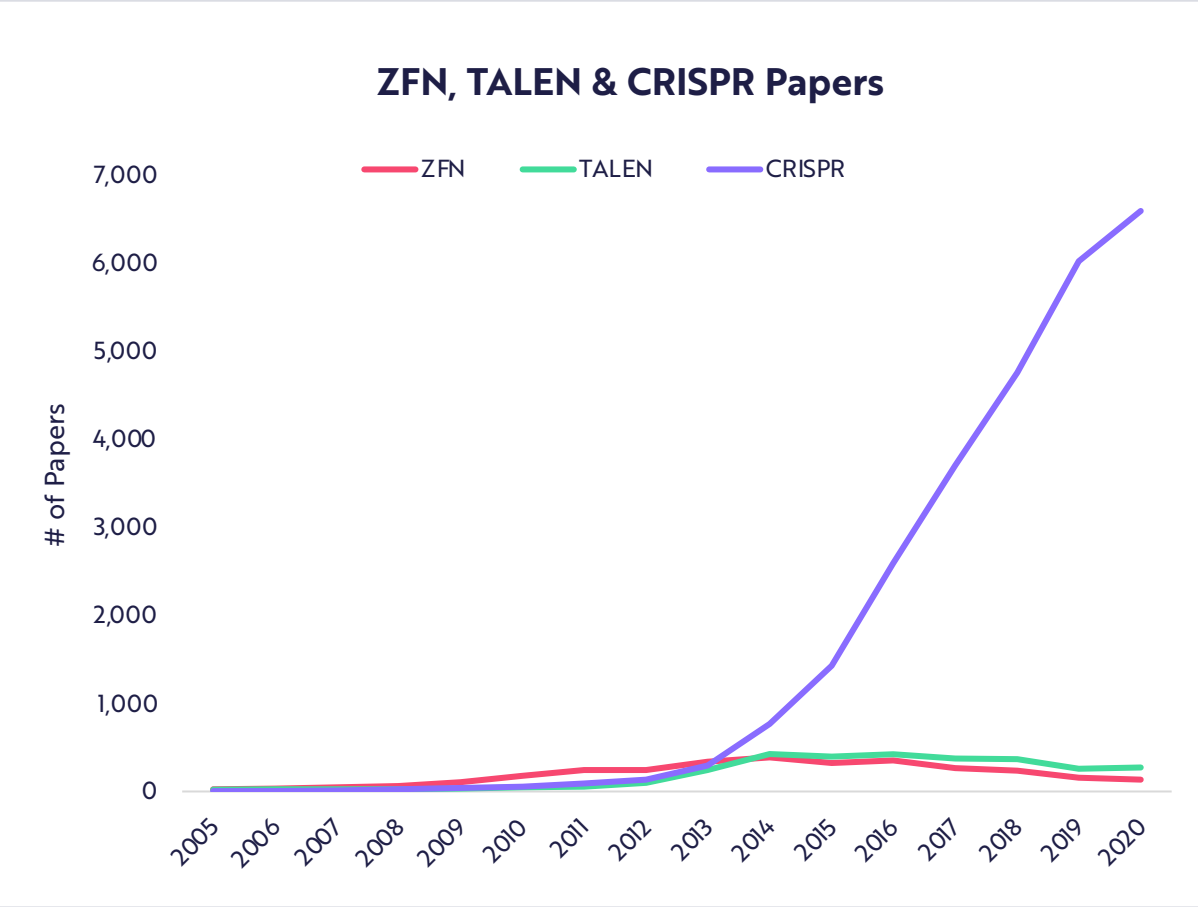


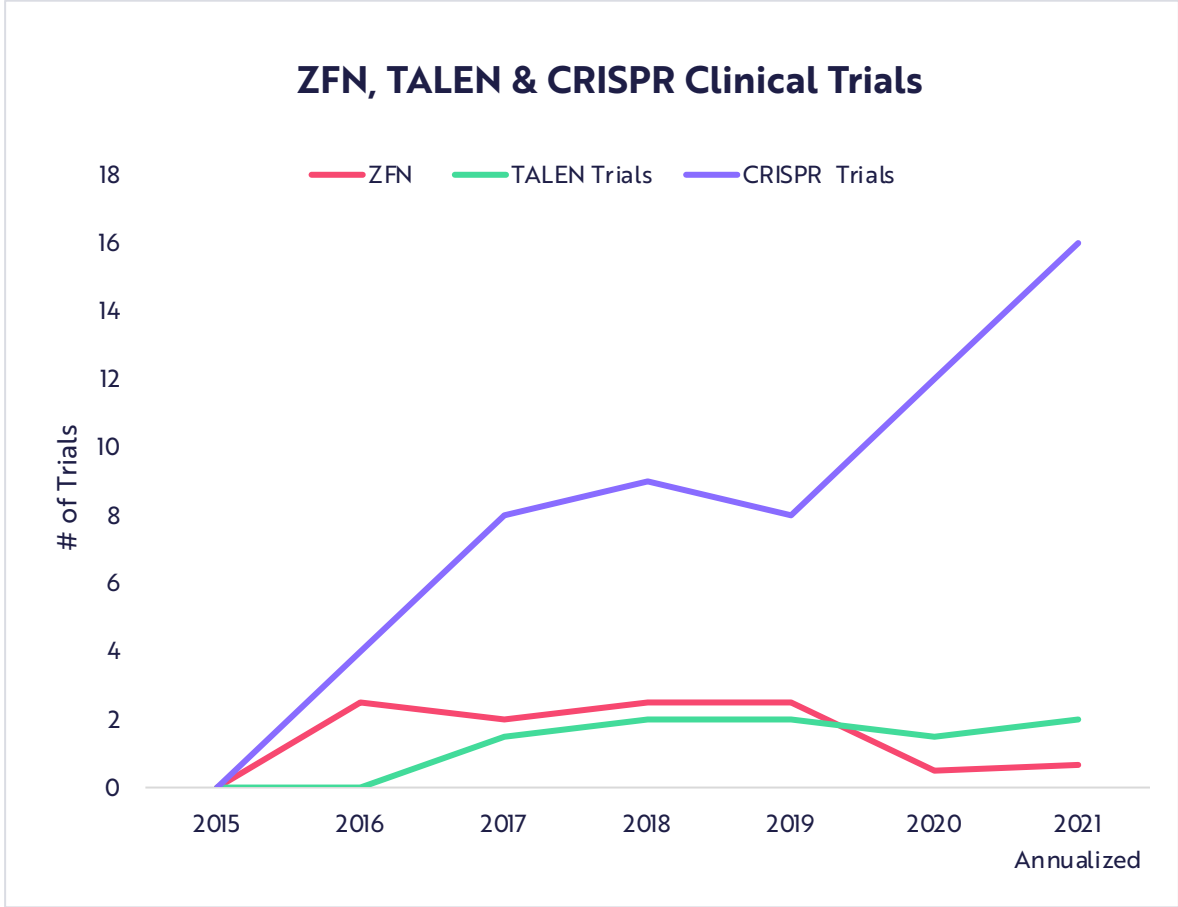
	ZFNs	TALENs	CRISPR
Cost	High	Low	Very Low
Time	Months	Weeks	Days
Technical Difficulty	High	Medium	Low
Targeting Mechanism	Protein-DNA interaction	Protein-DNA interaction	RNA/DNA interaction
Delivery	Two proteins around the target	Two proteins around the target	Guide RNA and Cas protein
Multiplex Editing	Very Difficult	Difficult	Not Difficult

- **ZFNs** (zinc finger nucleases) use engineered ZF repeat domains to target specific sites in host DNA and induce double stranded breaks (DSBs) with the nuclease.
- **TALENs** (transcription activator-like effector nucleases) targets host DNA using unique modular proteins and induce DSBs with the nuclease.
- **CRISPR** (Clustered Regularly Interspaced Short Palindromic Repeats) uses a protein-RNA complex to guide its nuclease to the target site.

Source: ARK Investment Management LLC, 2021

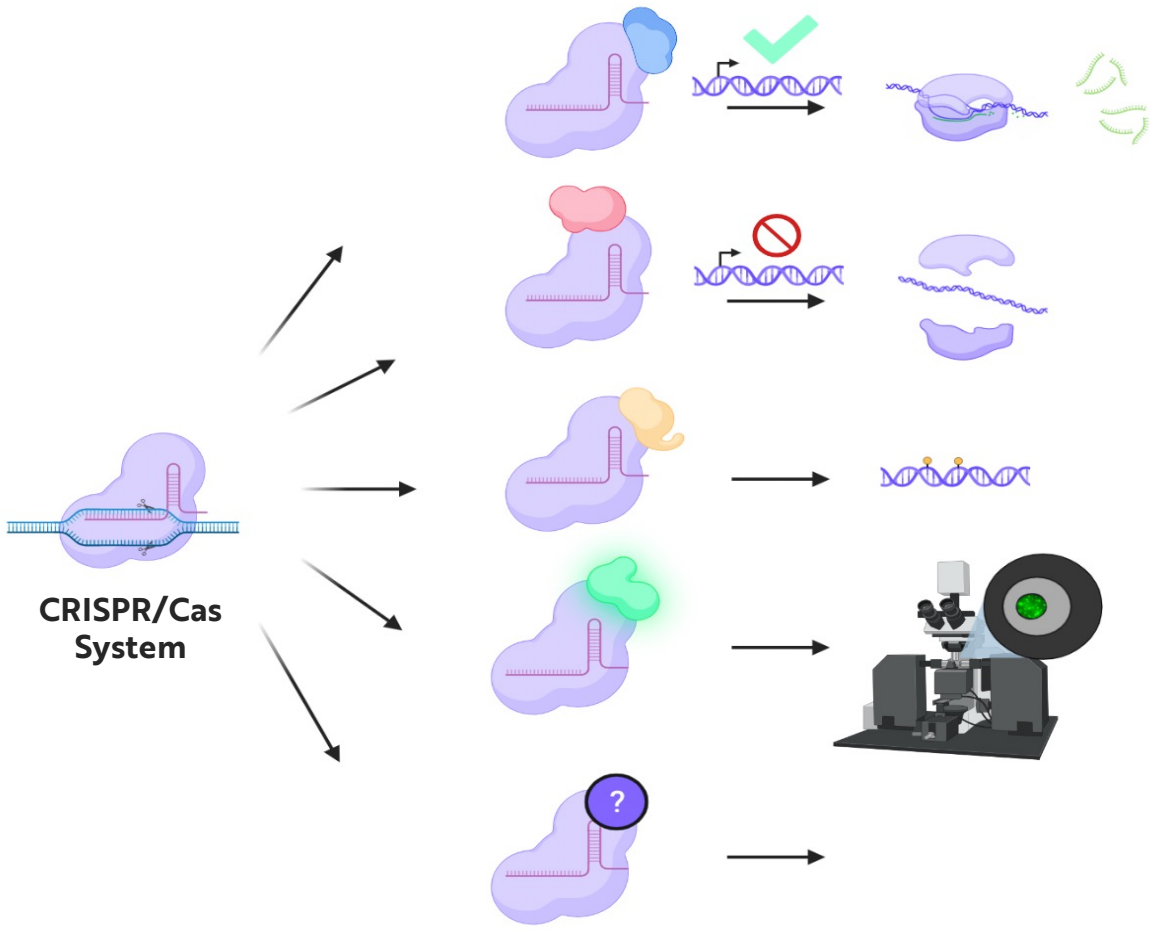
CRISPR Is Dominating Academic Research And Clinical Trials





Forecasts are inherently limited and cannot be relied upon. | For informational purposes only and should not be considered investment advice, or a recommendation to buy, sell or hold any particular security.
Source: Clairivate Analytics. Web of Science. Accessed 12/10/2021. National Library of Medicine (U.S.). (https://clinicaltrials.gov/. Accessed 12/10/2021

CRISPR Extends Beyond Gene Editing

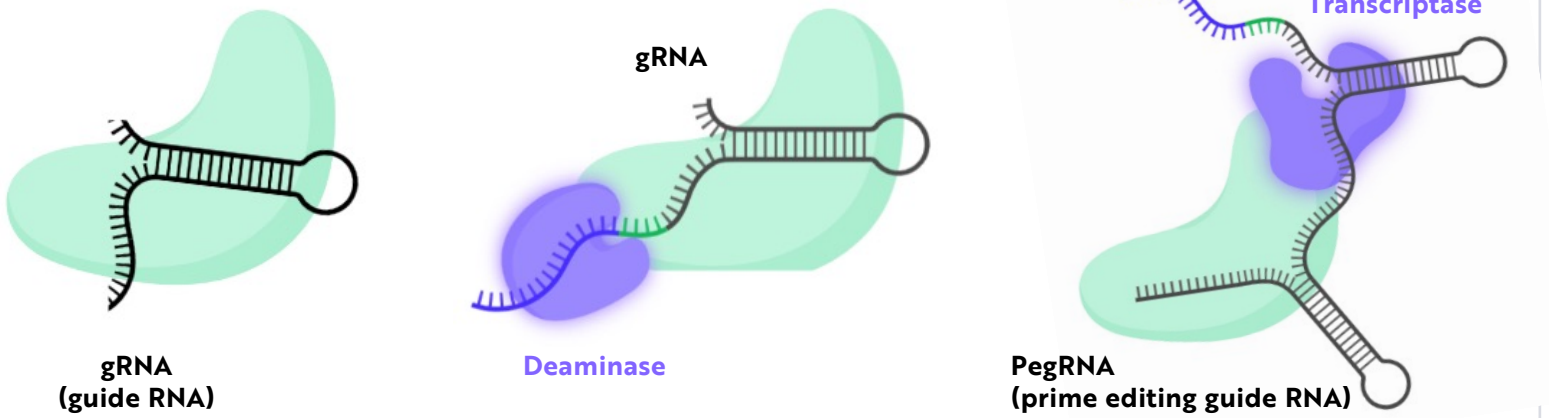


Function	Benefit/Application
Transcriptional Activation Recruiting RNA polymerases to express genes of interest	**Turns on genes that are dormant or not expressed**
Transcriptional Repression Blocking the expression of specific genes with CRISPR-directed repressor proteins	**Silences toxic genes and gene variants**
Epigenetic Control Controlling expression through the addition or removal of chemical moieties to DNA and its packaging proteins	**Turns genes on or off**
Diagnostic Imaging Visualizing the presence of disease variants or viral genetic material with CRISPR-mediated fluorescent reporters	**Lowers cost**

For informational purposes only and should not be considered investment advice, or a recommendation to buy, sell or hold any particular security.
Source: ARK Investment Management LLC, 2021. CRISPR/Cas9-Based Engineering of the Epigenome. Pulecio, Julian et al. Cell Stem Cell, Volume 21, Issue 4, 431 – 44. Zhang, F. (2019); Development of CRISPR-Cas systems for genome editing and beyond. Quarterly Reviews of Biophysics, 52, E6. doi:10.1017/S0033583519000052

CRISPR Functionality Is Increasing

Base and prime editing can address diseases like cardiomyopathy that cannot be cured today.



	CRISPR Nucleases	Base Editing	Prime Editing
Size	~4 kilobase (kb)	~5 kb	~6 kb
PAM (protospacer adjacent motif) Dependence*	High	High	Low
Breaks	Double stranded break	Single strand nick	Single strand nick
Clinical Variants Addressable	48%	59%	79%

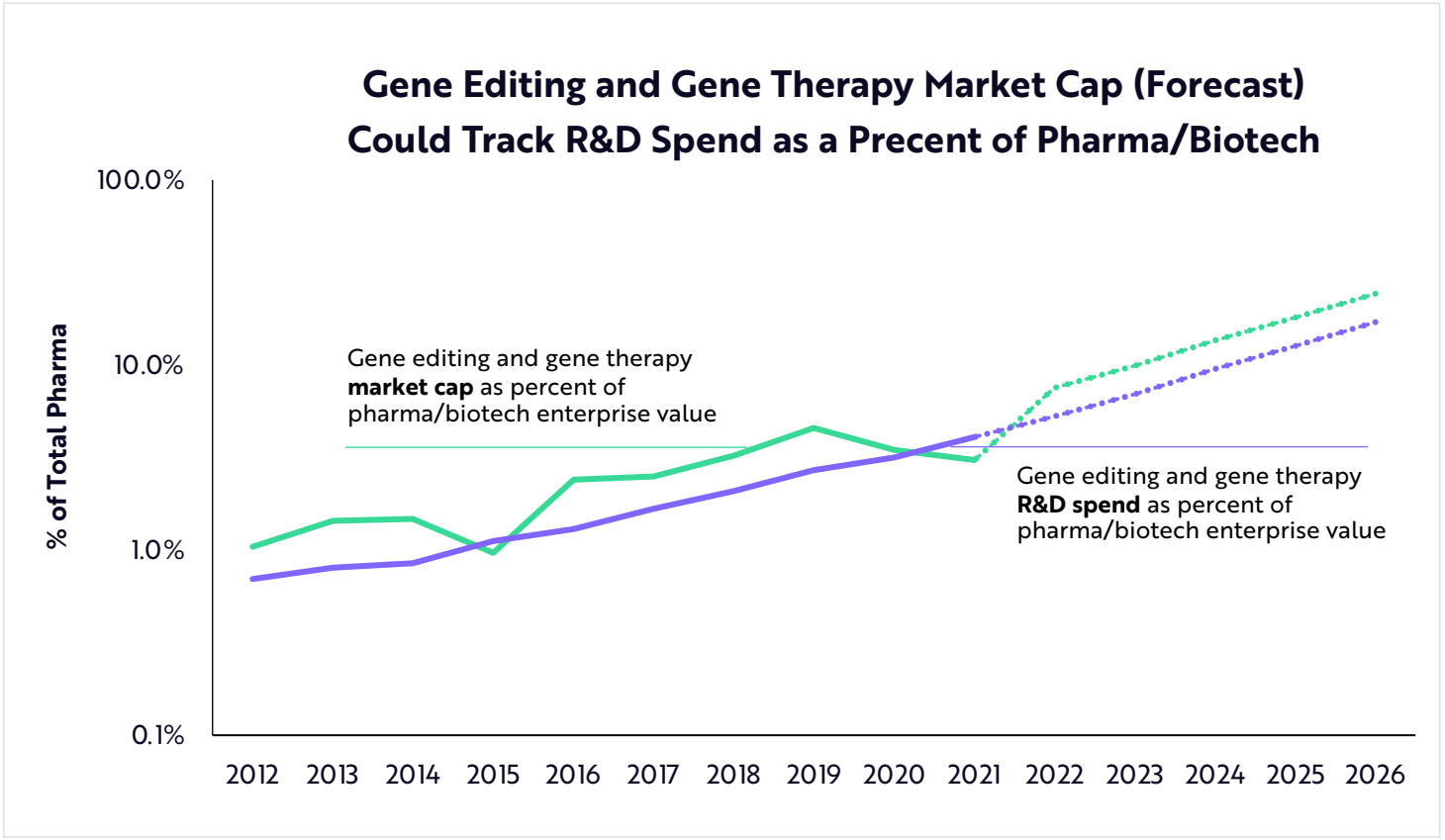
*PAM is the landing spot for CRISPR. It is required for a Cas nuclease to cut at the site of interest and is generally found 3-4 nucleotides downstream from the cut site.
Forecasts are inherently limited and cannot be relied upon. | For informational purposes only and should not be considered investment advice, or a recommendation to buy, sell or hold any particular security.
Source: ARK Investment Management LLC, 2021

Gene Editing And Gene Therapy Companies Could Reach Roughly $1.1 Trillion In Market Capitalization By 2026

Given potential cures for diseases, the share of research and development funding for gene therapy innovations should continue to rise.

By 2026, the share of total R&D spending devoted to gene editing and therapy companies could grow from 3% to 17%.

Gene editing and therapy market capitalization could scale 54% at a compound annual growth rate from roughly $130 billion to $1.1 trillion by 2026.



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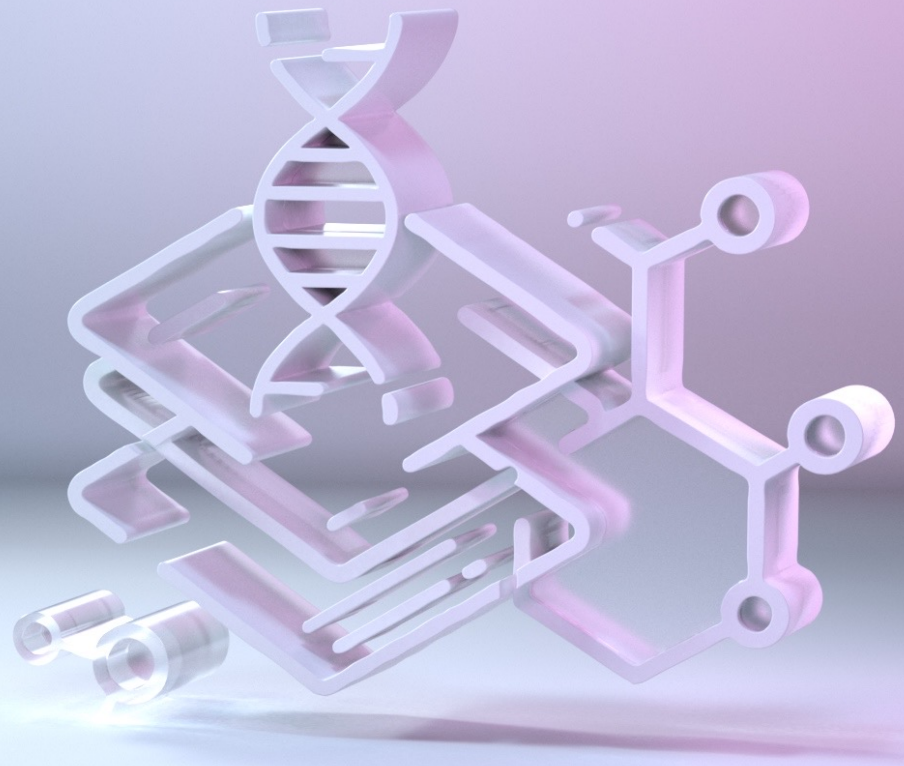
Source: ARK Investment Management LLC, 2021; PHrMa annual reports. Public filings of companies. Capital IQ. Equivate.
Assumes that gene editing and gene therapy companies continue to invest cashflow into R&D into a rate consistent with history and that returns on research capital within gene editing and gene therapy are consistent with history. Market value assumption embeds an assumption that the market will value gene editing and gene therapy pipeline assets at a premium to traditional pipeline assets

ARK INVEST

Multi-Omics

The Future of Molecular Biology

Research by Simon Barnett, ARK Analyst



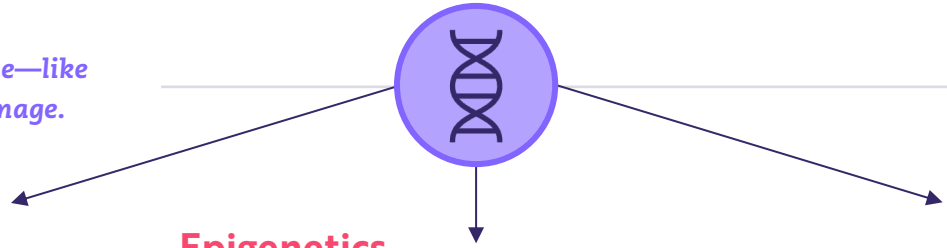
Leveraging the genome, transcriptome, proteome, and other 'omics, scientists are likely to translate groundbreaking discoveries into clinical solutions. New analytics and software tools, especially those focused on high-throughput proteomics, should allow scientists to unlock the codes to life, disease, and health.

According to ARK's research, the multi-omics revenue opportunity—including life science tools, basic and translational research, population health efforts, and molecular diagnostics—will scale at a 22% annual rate, from roughly $110 billion to $300 billion, during the next five years.

The Human Genome Project Finally Finished In 2021

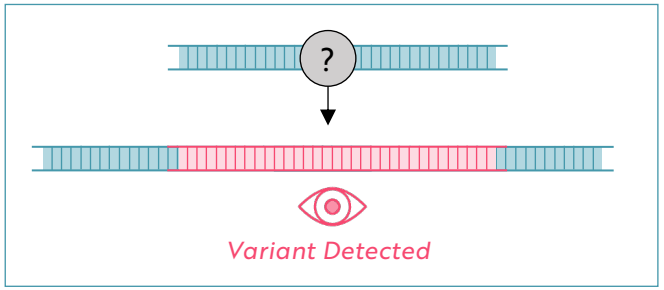
Created using **next-generation sequencing** (NGS), the 2003 human genome draft sequence was incomplete. Using a combination of long-read sequencing (LRS) methods, the Telomere-to-Telomere (T2T) Consortium finally published a complete human genome–discovering 200 million more base pairs (bps) of DNA and 1,500 *new* genes in the process.[1] ARK believes this monumental achievement is a harbinger of novel life science tools and methods that will surface previously hidden biology.

LRS enables unprecedented views of the genome—like adding color to a previously black and white image.



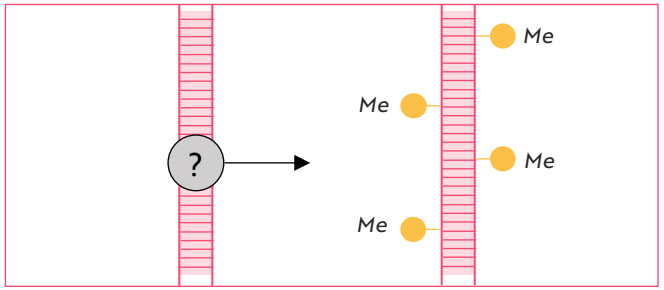
Structural Variation

LRS characterizes at least twice as many structural variants as SRS.[2]



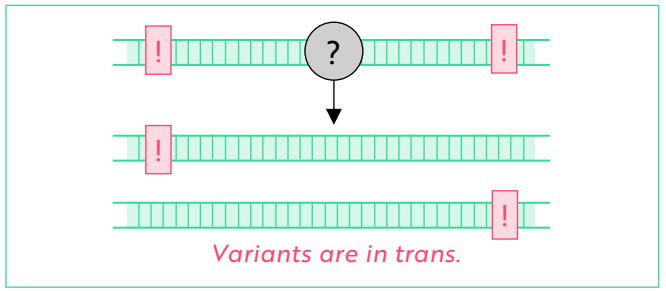
Epigenetics

LRS natively captures epigenetic information such as methylation without separate sample preparation.[3,4]



Long-Range Phasing

LRS discerns diploid genomes, allowing scientists to see if mutations are on "mom's side or dad's side."[5]



For informational purposes only and should not be considered investment advice, or a recommendation to buy, sell or hold any particular security.

[1] Nurk, Sergey, et al. "The Complete Sequence of a Human Genome." *BioRxiv*, Cold Spring Harbor Laboratory, 1 Jan. 2021, https://www.biorxiv.org/content/10.1101/2021.05.26.445798v1.
[2] "Epigenetics and Methylation Analysis." *Oxford Nanopore Technologies*, 26 Oct. 2021, https://nanoporetech.com/applications/investigation/epigenetics-and-methylation-analysis.
[3] Ebert, Peter, et al. "De Novo Assembly of 64 Haplotype-Resolved Human Genomes of Diverse Ancestry and Integrated Analysis ..." *BioRxiv*, Cold Spring Harbor Laboratory, 1 Jan. 2020, https://www.biorxiv.org/content/10.1101/2020.12.16.423102v1.
[4] "Direct Detection of DNA Methylation during Single-Molecule, Real-Time Sequencing." *PacBio*, 2010, https://www.pacb.com/publications/direct-detection-of-dna-methylation-during-single-molecule-real-time-sequencing/.
[5] Botton, Mariana R., et al. "Phased Haplotype Resolution of the SLC6A4 Promoter Using Long-Read Single Molecule Real-Time Sequencing." *MDPI*, Multidisciplinary Digital Publishing Institute, 12 Nov. 2020, https://www.mdpi.com/2073-4425/11/11/1333.

The Central Dogma Describes How Information Flows Downstream Through Biological Systems

In simple terms, the Central Dogma states that **DNA** (the genome) is transcribed into **RNA** (the transcriptome), which ultimately is translated into **protein** (the proteome).[1] Proteins carry out virtually all critical-to-life functions but, when altered, can cause disease. Understanding the interactions between and among the pillars of the Central Dogma, we will improve our ability to make predictions, diagnoses, and leaps of fundamental, biological insight.

- Primary Sequence
- Phasing
- Epigenetics
- Small Variants
- Complex Variants

- Gene Expression
- Isoform Expression
- RNA Modifications

- Protein Quantification
- Post-Translational Modifications
- Proteoform Detection

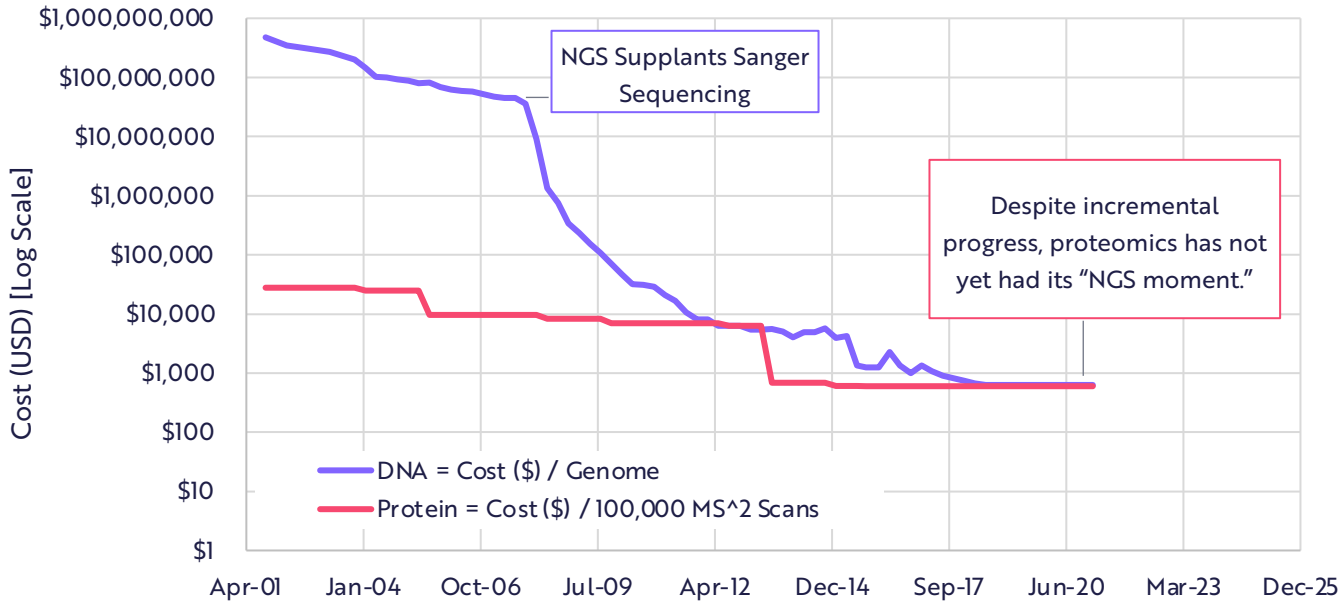
Nucleus | **Nuclear Membrane** | **Cell Interior** | **Cell Membrane**

[1] Malone, Cindy S. "Central Dogma of Genetics - CSUN.EDU." *csun.edu*, https://www.csun.edu/~cmalone/pdf360/Ch13-1transcription.pdf.

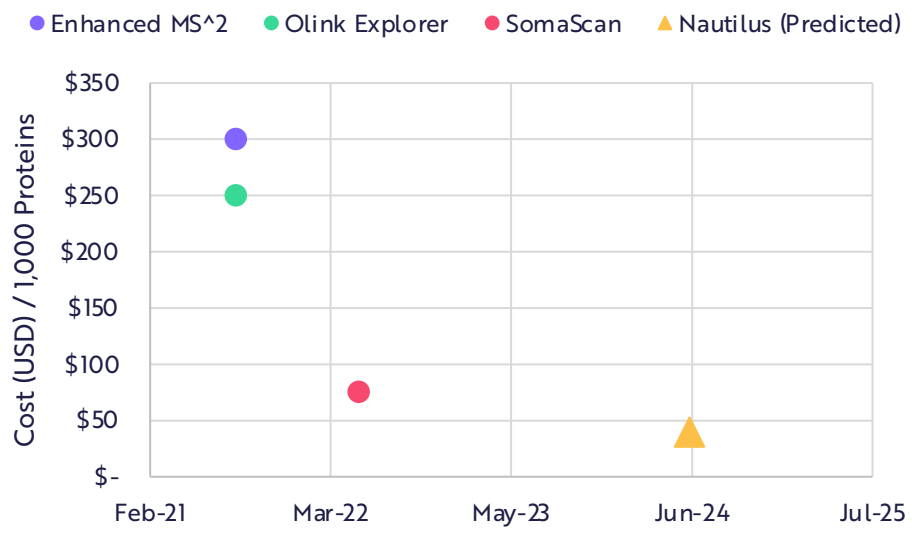
Comprehensive Clinical Proteomics Is Challenging For Myriad Reasons, Including High Costs

Blood serum (plasma) is the only feasible sample type that offers an unbiased view of the complex human proteome. ARK believes that clinical proteomics offers enormous potential as an **indicator of human health** and will be key to understanding the inner workings of the Central Dogma.[1]

DNA And High-Res Proteomics Cost Decline Over 20 Years[2]



New Technologies Are Causing A Steep Cost-Decline[3] in Proteomics

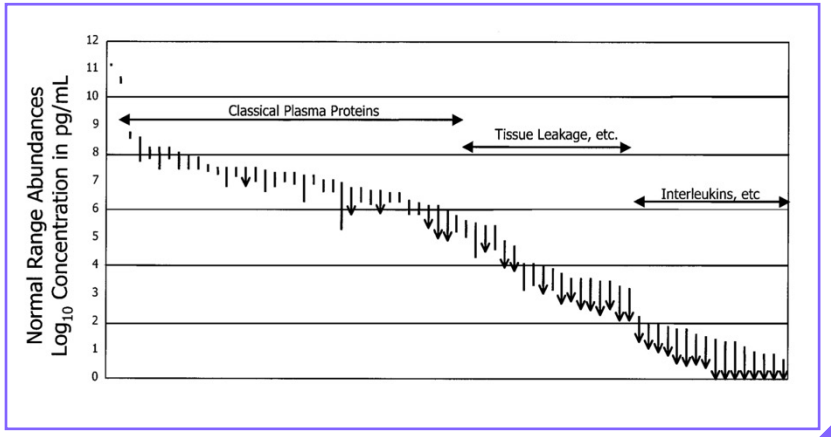


MS^2 = "Tandem Mass Spectrometry", a common method for analyzing complex proteomic samples like blood plasma.
Forecasts are inherently limited and cannot be relied upon. | For informational purposes only and should not be considered investment advice, or a recommendation to buy, sell or hold any particular security.
[1] Blume, John E., et al. "Rapid, Deep and Precise Profiling of the Plasma Proteome with Multi-Nanoparticle Protein Corona." *Nature News*, Nature Publishing Group, 22 July 2020, https://www.nature.com/articles/s41467-020-17033-7.
[2] ARK Investment Management LLC, 2021, Data sourced from the National Human Genome Research Institute (NHGRI) and Nature Reviews, Chemistry
[3] ARK Investment Management LLC, 2021, Data sourced from Seer (SEER), Olink Proteomics (OLK), SomaLogic (SLGC), and Nautilus (NAUT)

Mass Spectrometry (MS) Is Undergoing A Renaissance

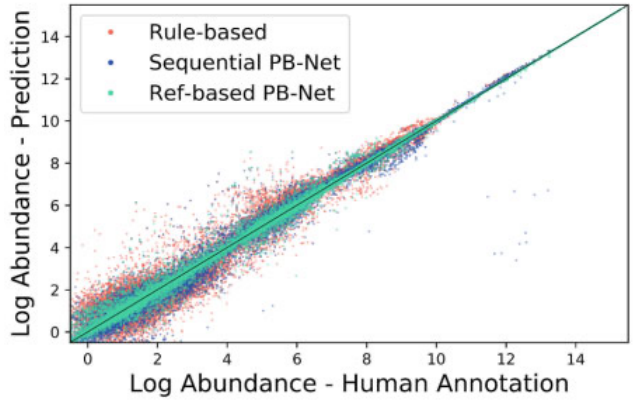
MS is a technique to analyze complex proteomic samples one at a time, taking advantage of different masses and charges of proteins. MS has been difficult to scale as it requires manual analysis that often fails to detect protein levels in plasma.[1] Novel sample prep and analysis **that bookend MS** are beginning to address its shortcomings. Because MS is ubiquitous, the market is likely to adopt these advancements in short order.

Novel sample prep methods like **tunable nanoparticles** can compress the plasma proteome's dynamic range, making low- and high-abundance proteins easier to detect.[1,2]



- New MS instruments enable clever methods like **Scanning SWATH** to exploit additional data.[3]
- **Scanning SWATH** improves the detection of plasma proteins by 70% (CV: 6.4%) and collapses sample prep time to five minutes.

Deep neural-network (NN) tools like **OpenPIP** shorten the time necessary to analyze MS spectral data.[4]



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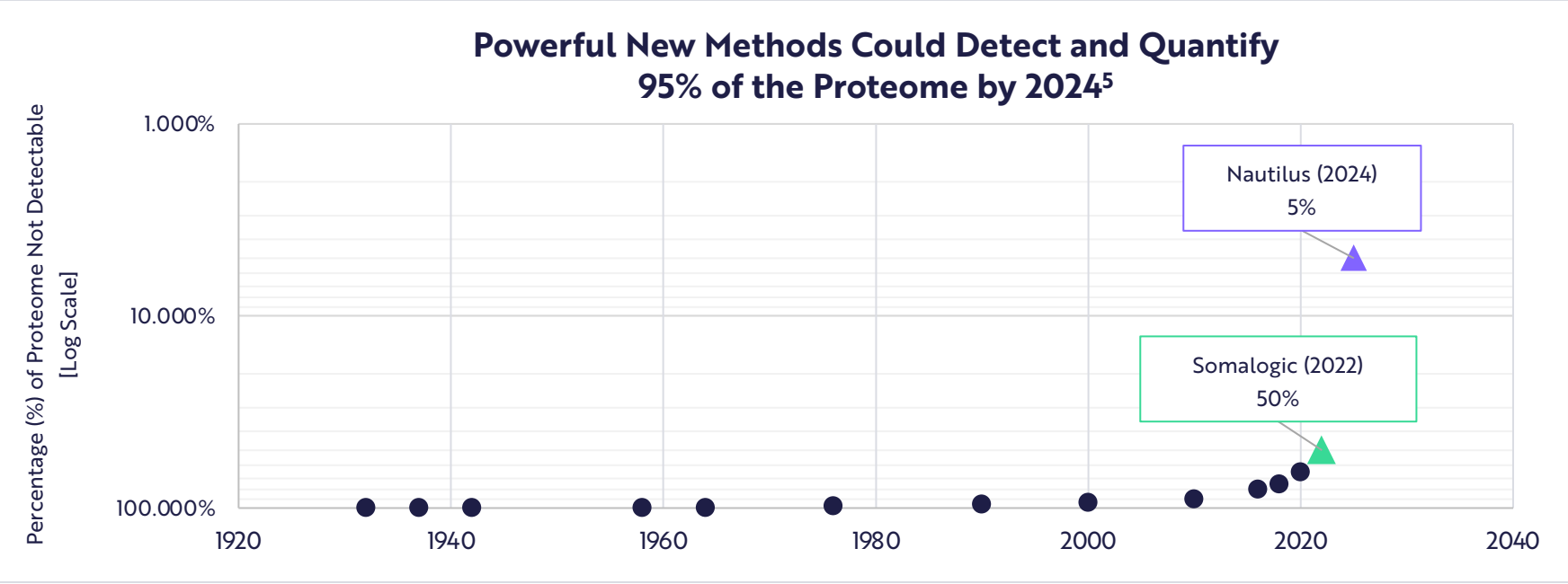
[1] Blume, John E., et al. "Rapid, Deep and Precise Profiling of the Plasma Proteome with Multi-Nanoparticle Protein Corona." *Nature News*, Nature Publishing Group, 22 July 2020, https://www.nature.com/articles/s41467-020-17033-7.
[2] Anderson, Norman, and N. Leigh Anderson. "The Human Plasma Proteome." *Molecular and Cellular Proteomics*, https://www.mcponline.org/article/S1535-9476(20)34246-8/fulltext.
[3] Messner, Christoph B., et al. "Ultra-Fast Proteomics with Scanning Swath." *Nature News*, Nature Publishing Group, 25 Mar. 2021, https://www.nature.com/articles/s41587-021-00860-4.
[4] Biosciences, OpenPIP | InterVenn. "OpenPIP: Intervenn Biosciences." *OpenPIP | InterVenn Biosciences*, https://intervenn.com/enabling-technologies/openpip/.

Scientists Are Creating Methods To Detect Previously Hidden Proteins

NGS **massively parallelized** the analysis of DNA and RNA data, enabling a significant increase in research experiments.[1] Several new detection technologies could parallelize the detection and analysis of proteins.[2,3,4] ARK estimates that scientists will be able to quantify **more than half*** the human plasma proteome in a single experiment by the end of 2022.[2]



- Few diseases have single-protein signatures, necessitating the use of **multiprotein tests**.[6]
- NGS-based tests that include many genes could pave the way for protein **"panels."**
- Multivariate **machine learning** (ML) and **bioinformatics** could help scientists understand the surge in proteomics data—accelerating the translation from proof-of-concept to clinical practice.

**Refers to half of the set of canonical human proteins (>10,000 proteins), not proteoforms—which will be elaborated on in the next slide.*

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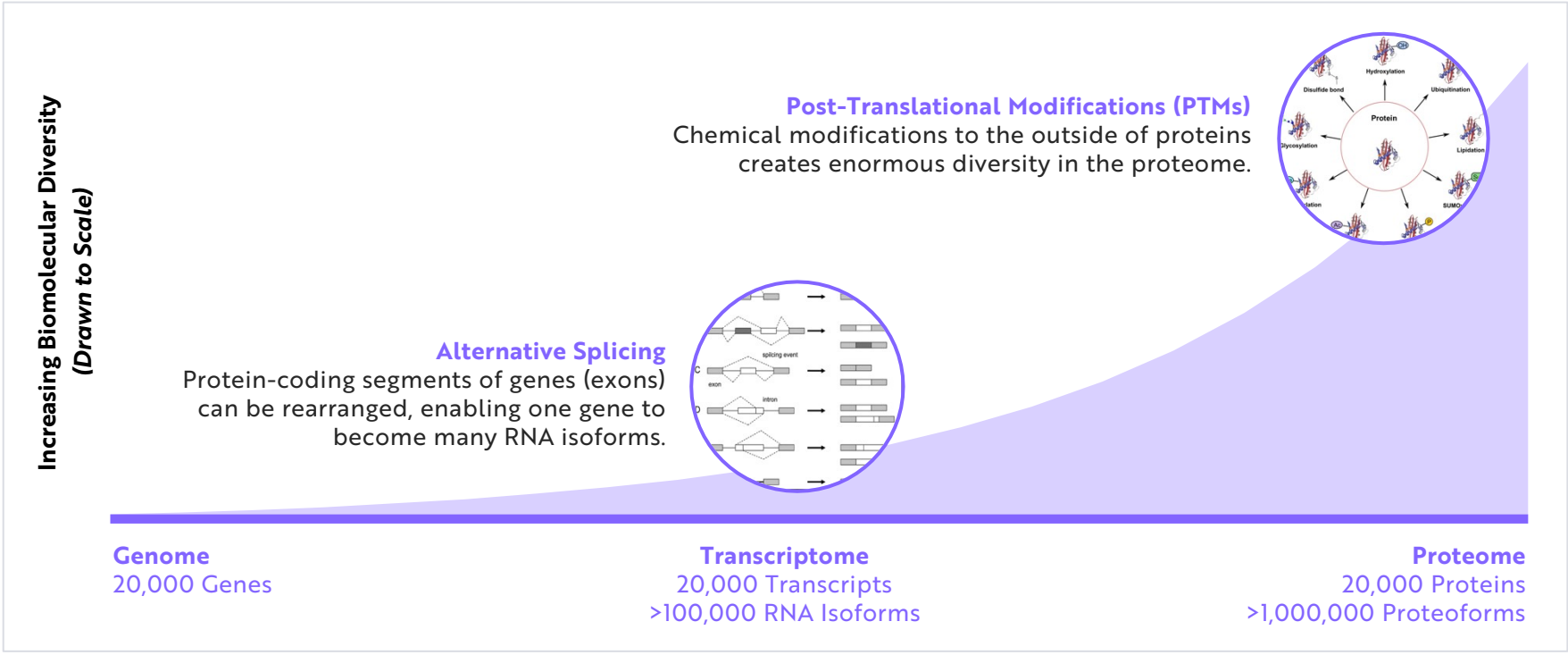
[1] "DNA Sequencing Costs: Data." *Genome.gov*, https://www.genome.gov/about-genomics/fact-sheets/DNA-Sequencing-Costs-Data.
[2] "Technology." *SomaLogic*, 15 Nov. 2021, https://somalogic.com/technology/.
[3] "Technology." *Nautilus Biotechnology*, https://www.nautilus.bio/technology/.
[4] "Olink Explore 3072." *Olink*, 29 Nov. 2021, https://www.olink.com/products-services/explore/.
[5] ARK Investment Management LLC, 2021, Data sourced from the Journal of Molecular and Cellular Proteomics
[6] Anderson, Norman, and N. Leigh Anderson. "The Human Plasma Proteome." *Molecular and Cellular Proteomics*, https://www.mcponline.org/article/S1535-9476(20)34246-8/fulltext.

Each Layer Of The Central Dogma Adds To Its Complexity

While the ~20,000 genes in our genomes create ~20,000 canonical proteins, our transcriptomes and proteomes can harbor hundreds of thousands of unique molecules.[1] Biological processes like alternative splicing and post-translational modification, for example, add diversity and complexity, as shown below.



- ARK believes that **semiconductor** and **nanopore-based** sequencing technologies are best suited to analyze full-length RNA isoforms, protein sequence variants, and other processes like alternative splicing and PTMs.[2,3,4]
- The scalability and maturity of semiconductor and nanopore-based sequencing technologies may help translate novel research findings into clinical practice.
- Algorithms like **AlphaFold v.2** can transform protein sequence data into accurate 3D predictions of proteoform structure, creating a quick and inexpensive path to hypotheses and drug discoveries.[5]

[1] September 12, 2017, et al. "Intro to Proteogenomics." *National Cancer Institute*, https://www.cancer.gov/about-nci/organization/ccg/blog/2020/intro-proteogenomics-central-dogma.
[2] Al'Khafaji, Aziz M., et al. "High-Throughput RNA Isoform Sequencing Using Programmable Cdna Concatenation." *BioRxiv*, Cold Spring Harbor Laboratory, 1 Jan. 2021, https://www.biorxiv.org/content/10.1101/2021.10.01.462818v1.
[3] "See beyond Color - Quantum-Si Products and Technology." *Quantum*, 21 June 2021, https://www.quantum-si.com/products-and-technology/.
[4] https://orcid.org/0000-0003-2083-6027, Winston Timp, et al. "Beyond Mass Spectrometry, the next Step in Proteomics." *Science Advances*, 10 Jan. 2020, https://www.science.org/doi/10.1126/sciadv.aax8978.
[5] Jumper, John, et al. "Highly Accurate Protein Structure Prediction with Alphafold." *Nature News*, Nature Publishing Group, 15 July 2021, https://www.nature.com/articles/s41586-021-03819-2.

New Tools And Methods Can Solve Biological Mysteries

Using population-scale **genomic** and plasma **proteomic** data, biostatisticians can uncover **pQTLs**—DNA mutations that alter protein abundance.[1]

DNA

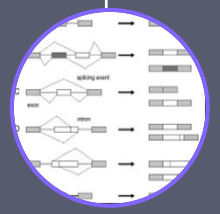
Transcription

RNA

Translation

Protein

Phenotype



Using LRS-enabled **RNA isoform analysis**, scientists can compute **protein sequences** and understand **alternative splicing**—a key regulatory process that gives rise to RNA diversity.[2]

Nucleus

Nuclear Membrane

Cell Interior

Cell Membrane

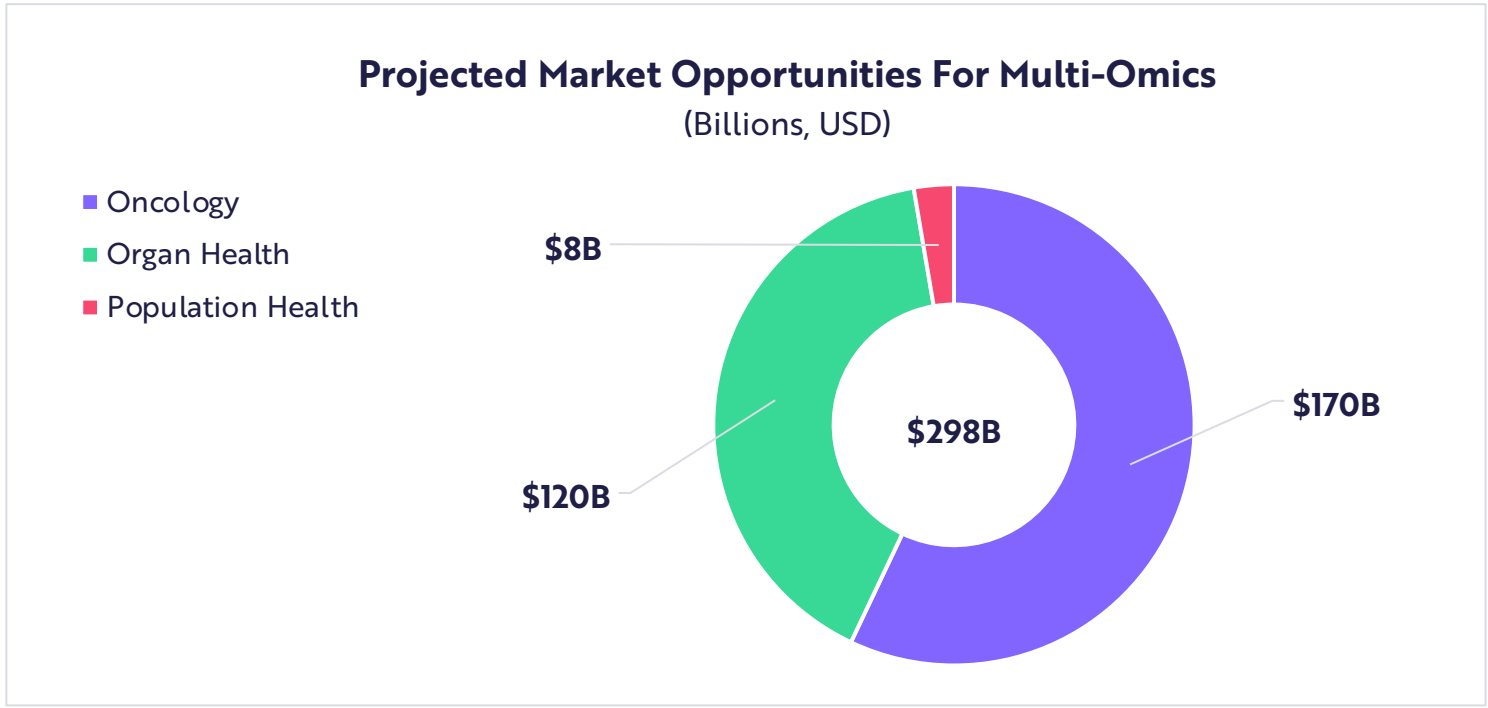
[1] Malone, Cindy S. "Central Dogma of Genetics - CSUN.EDU." *csun.edu*, https://www.csun.edu/~cmalone/pdf360/Ch13-1transcription.pdf.

Multi-Omics Could Evolve From $110 Billion To A $300 Billion Revenue Opportunity

We believe the future of molecular biology is based on multi-omics techniques that integrate pillars of the Central Dogma. Based on our research, multi-omics—including life science tools, basic and translational research, population health efforts, and molecular diagnostics—could impact oncology, organ health, and population health, scaling at a 22% annual rate from $110 billion to roughly $300 billion during the next five years.[1]

As costs decline, molecular diagnostic tests that combine DNA, RNA, and proteins should detect disease more accurately and comprehensively than existing tests.

Over the next five years, ARK expects that **liquid biopsies for cancer, organ health, and population-scale studies should scale exponentially**, thanks to the declining costs of genomics, transcriptomics, and proteomics technologies.



MRD = Minimal Residual Disease

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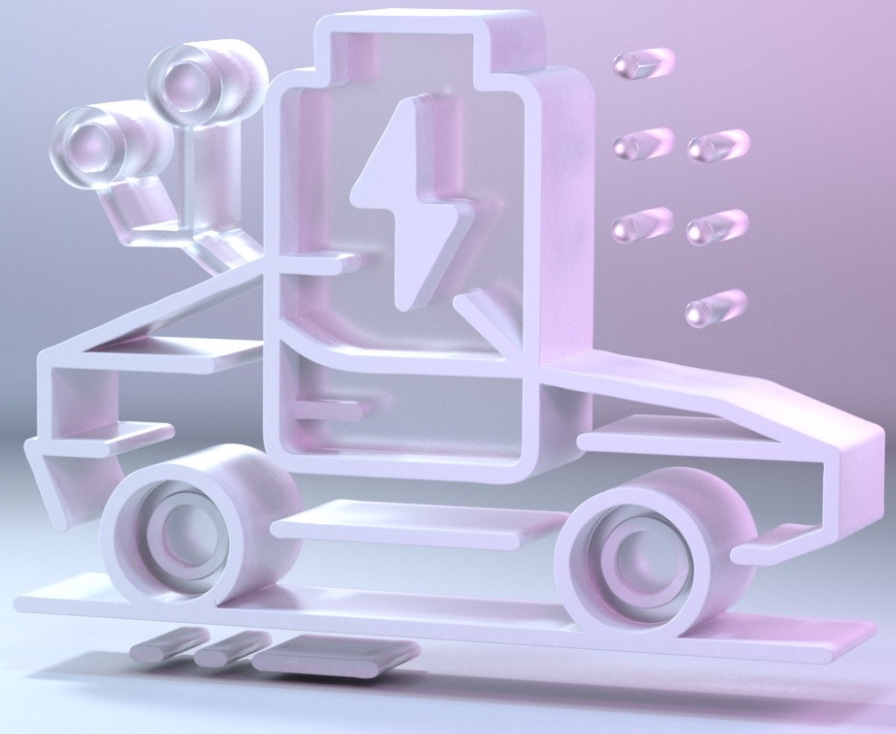
[1] ARK Investment Management LLC, 2021, Data sourced from Surveillance, Epidemiology, and End Results (SEER), SomaLogic (SLGC), and the American Society of Human Genetics (ASHG)

ARK INVEST

Electric Vehicles

En Route to Sticker-Price Parity with Gas-Powered Cars

Research by Sam Korus, ARK Analyst

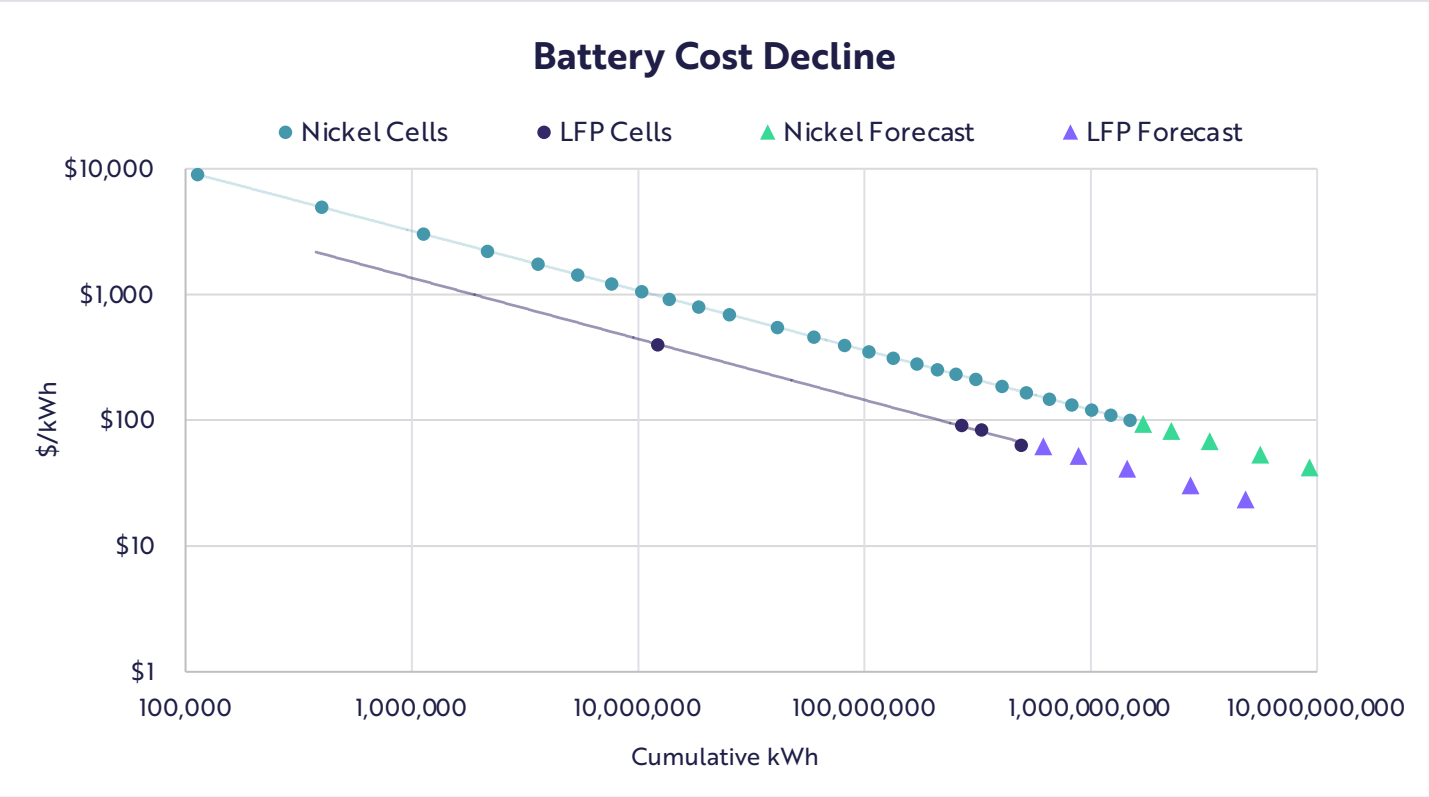


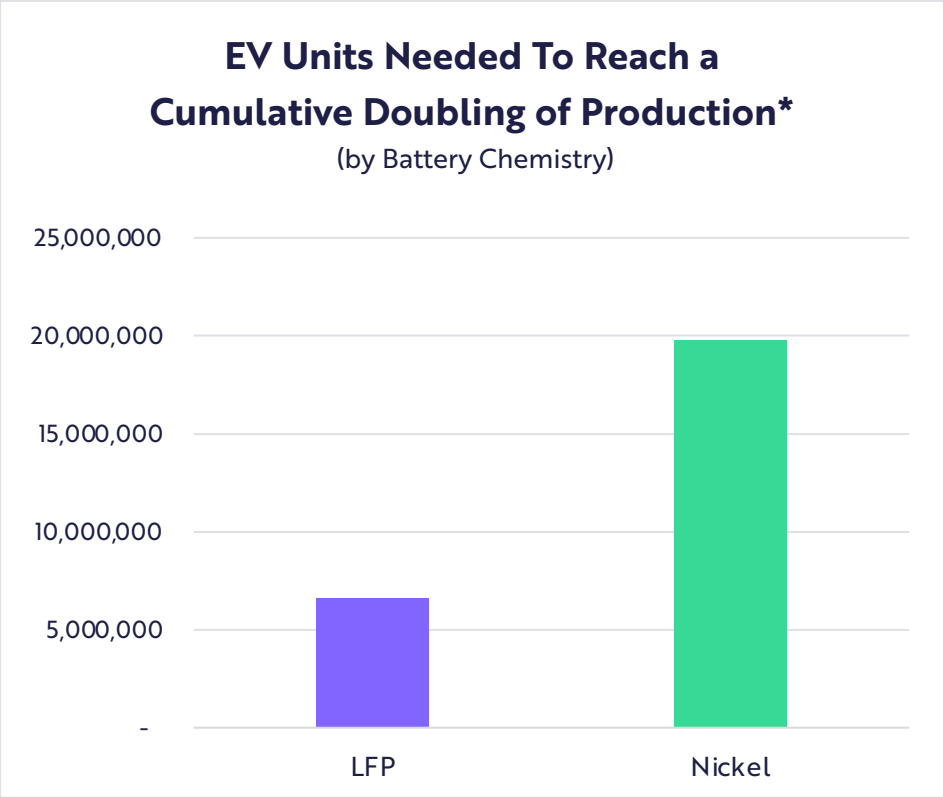
As their range increases, the prices of electric vehicles (EVs) are declining, overcoming the most significant barriers to customer adoption.

Based on Wright's Law, ARK forecasts that EV sales will increase roughly eightfold, or a 53% annual rate, from 4.8 million in 2021 to 40 million units in 2026. In our view, the biggest downside risk to our forecast is whether traditional automakers will be able to transition successfully to electric autonomous vehicles.

Wright's Law Has Modeled The Decline In Battery Costs Accurately

The largest cost component of an EV is its battery, the declining cost of which will be critical to reaching sticker-price parity with gas-powered vehicles. According to Wright's Law, for every cumulative doubling of units produced, battery cell costs will fall by 28%. Lithium iron phosphate (LFP) cells, which are less expensive and at a lower production base than nickel cells, could hasten the cost and price declines.





*EV units needed to reach a cumulative doubling of production from todays levels are higher than one might expect from the current size of the EV fleet because of the use of batteries outside the EV industry.
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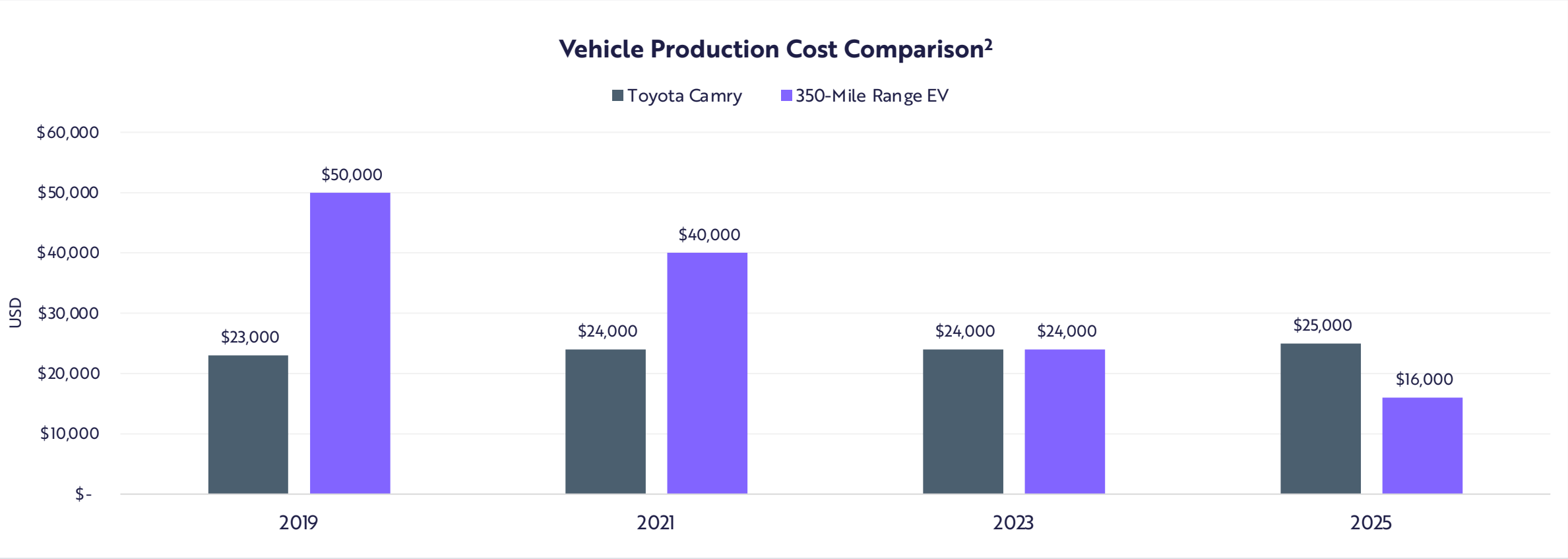
Sources: Data from: ARK Investment Management LLC, 2021, EV Volumes, Avicenne Energy, Bloomberg New Energy Finance, Snow Bull Capital, ICCSino, GGII, JP Morgan, CIAPS, https://onlinelibrary.com/doi/10.1002/ese3.47, https://pushevs.com/2021/08/10/this-is-why-byd-blade-battery-is-ahead-of-competition/

Electric Vehicle Costs Could Rival Gas-Powered Options In 2023

The total cost of ownership for a like-for-like EV dropped below that of a Toyota Camry in 2019.[1] EV production costs and sticker prices are likely to drop below those of gas-powered vehicles in the next one to two years and undercut them by 25-35% in 2025.



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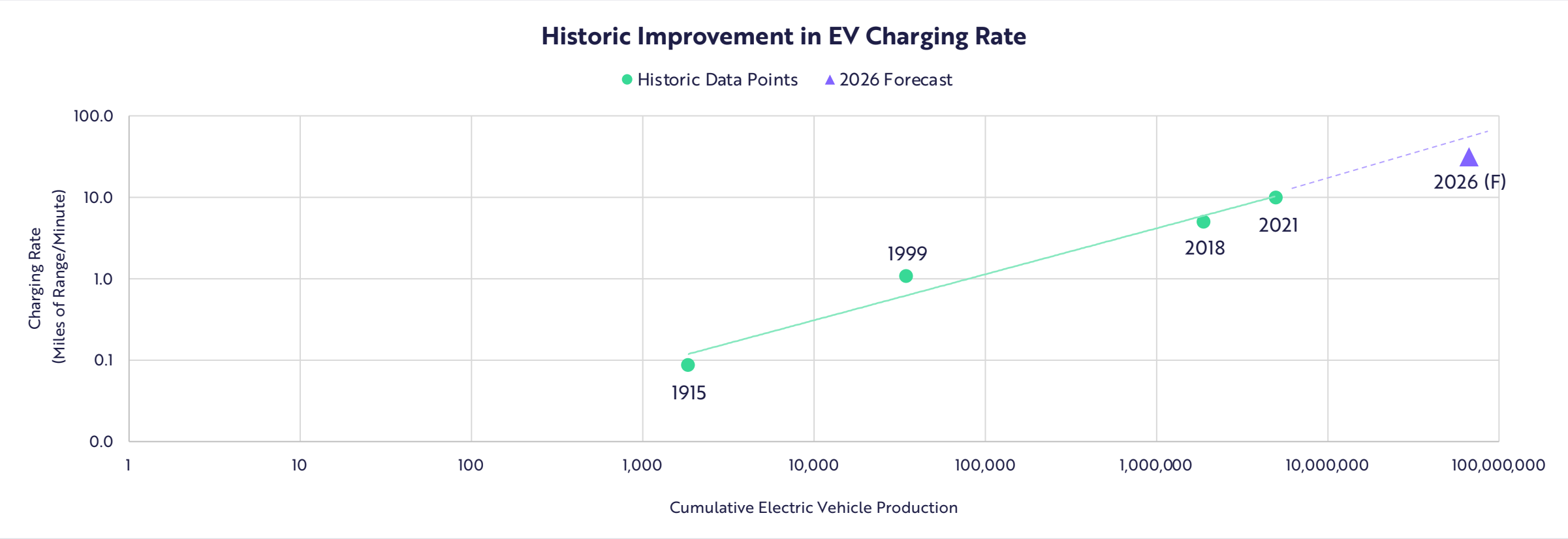
Source: ARK Investment Management LLC., 2021. Assumes a 5% gross margin relative to MSRP (Manufacturer Suggested Retail Price)
[1] Total cost of ownership includes savings from gas, maintenance, insurance, and resale value.
[2] Numbers may differ from projections in previous years as this year's Big Ideas focuses on costs rather than price and incorporates new battery cost decline estimates.

Wright's Law Also Models Improvements in EV Charging Rates

The ability to charge an EV quickly is impacted by both the vehicle and the charging infrastructure. Once EV charging rates reach an acceptable level, ARK expects the industry will optimize for other features like autonomous driving, safety, and possibly entertainment.



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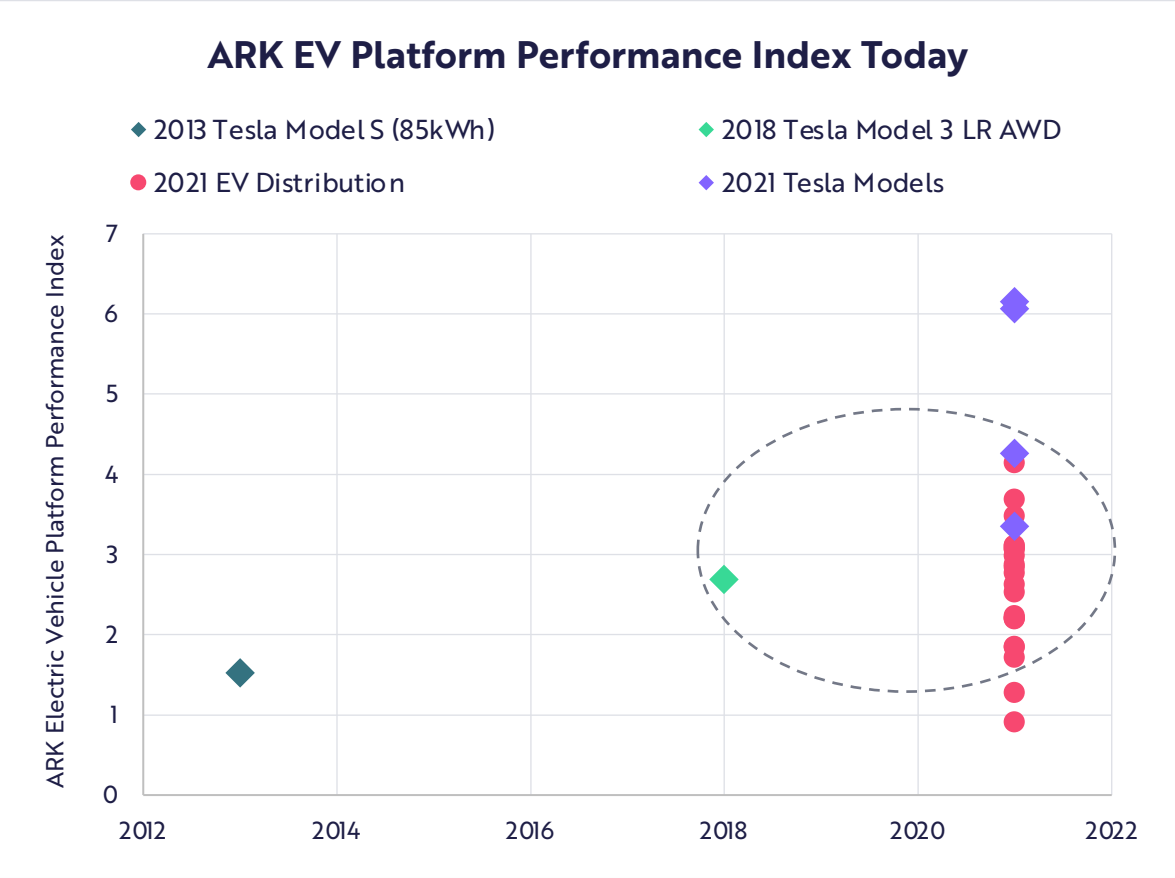
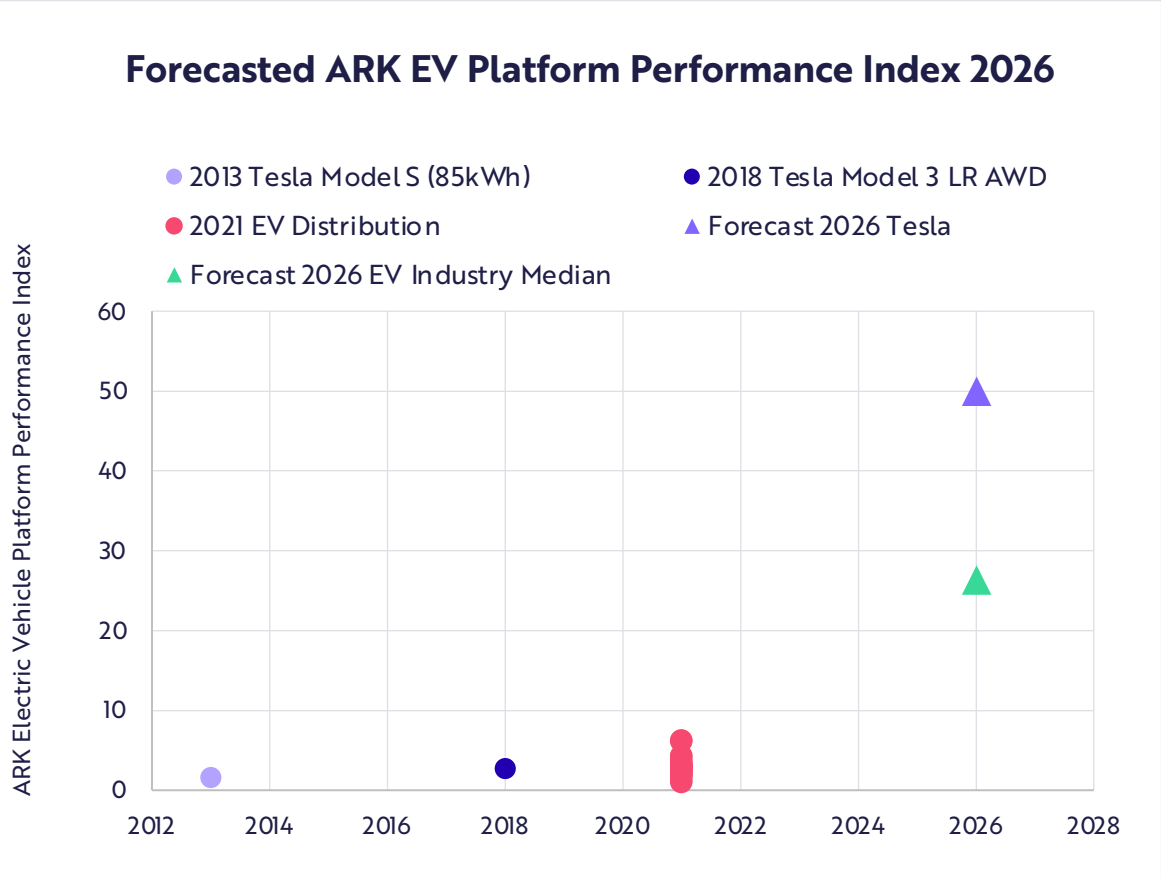
Source: ARK Investment Management LLC, 2021

EV Performance Is Improving

ARK's research shows that the median performance of EVs in 2021 is approaching Tesla's performance in 2018.
Both should continue to improve.

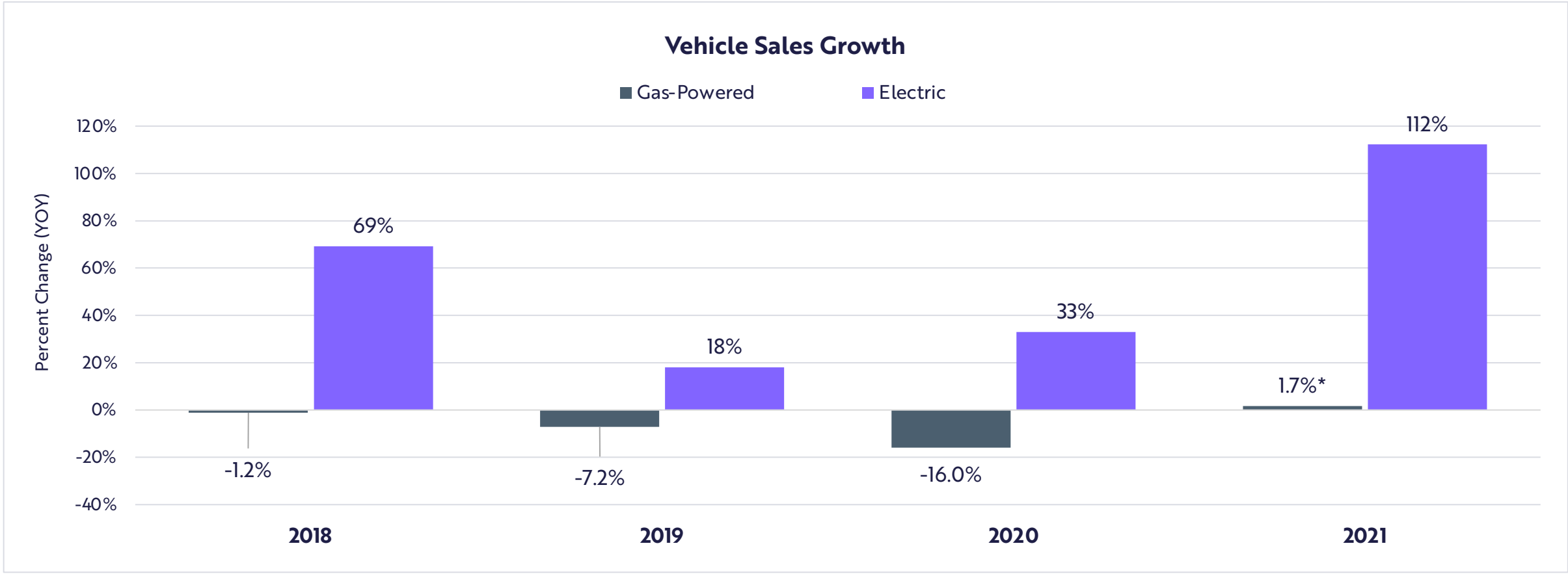




Forecasts are inherently limited and cannot be relied upon. | For informational purposes only and should not be considered investment advice, or a recommendation to buy, sell or hold any particular security.
Note: Index is calculated by dividing the charging rate (range added per minute) by vehicle cost. ARK believes charging rate is a good metric as it encapsulates efficiency, range, and power capabilities of the system.
Source: ARK Investment Management LLC, 2021.

Electric Vehicle Sales Continue To Take Share

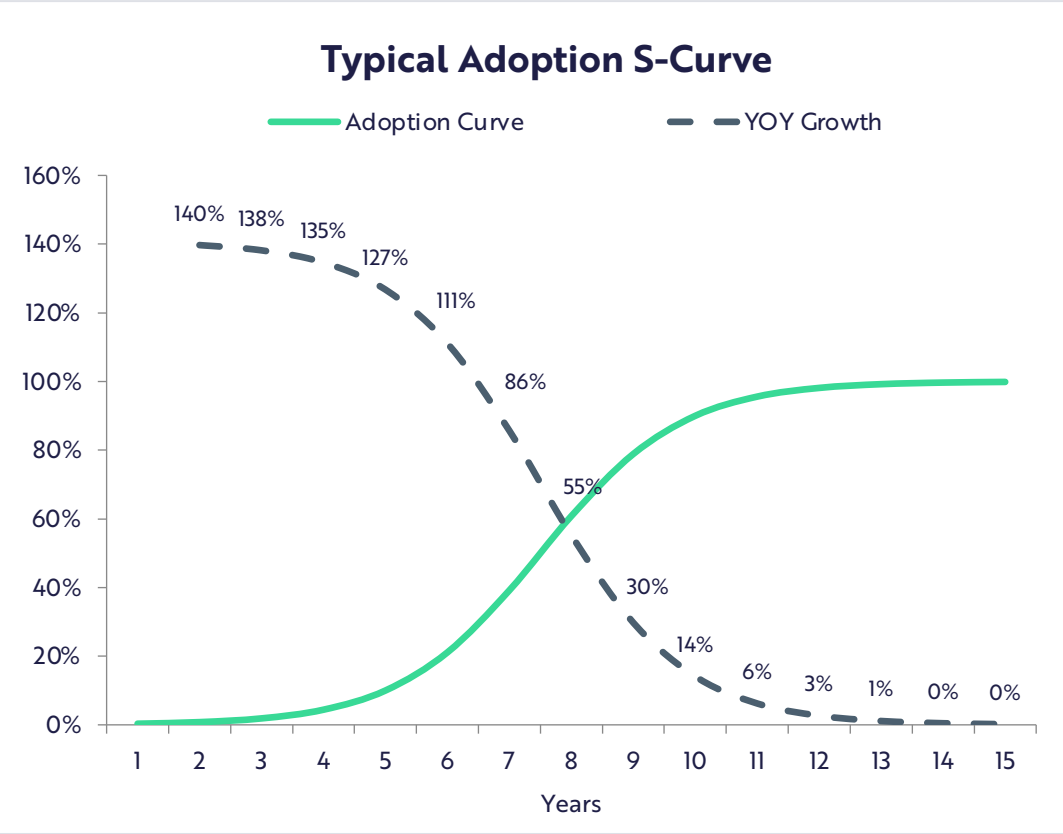
While sales of gas-powered vehicles recovered slightly in 2021, EV sales soared and continued to gain share globally.

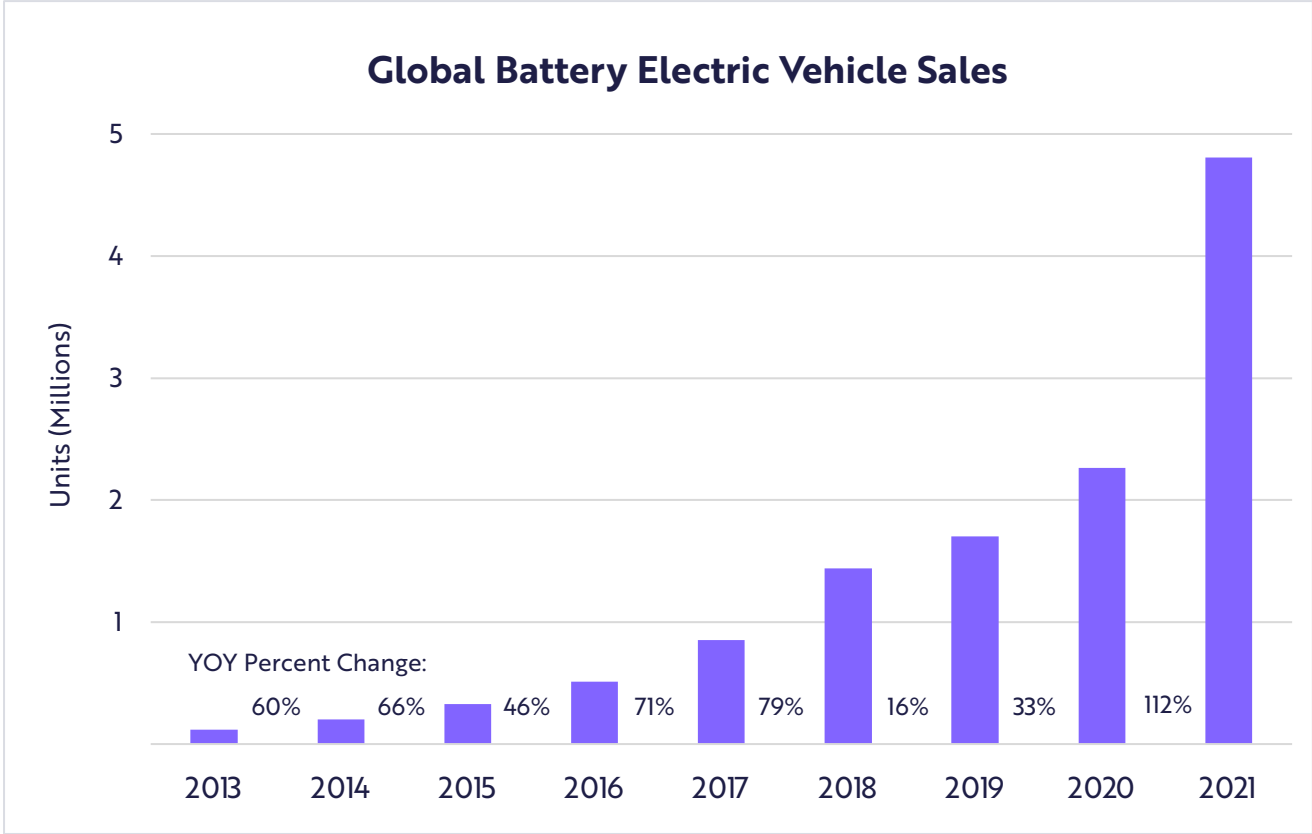


* Estimates. At the time publication official sales numbers were not available yet.
Forecasts are inherently limited and cannot be relied upon. | For informational purposes only and should not be considered investment advice, or a recommendation to buy, sell or hold any particular security.
Sources: ARK Investment Management LLC, Data from: "EV Data Center." EV, https://www.ev-volumes.com/datacenter/, Automotive Industry Outlook. https://www.cargroup.org/wp-content/uploads/2019/02/Wall.pdf.

Electric Vehicles Are Breaking Traditional S-Curve Dynamics

In a typical s-curve adoption cycle, the growth of a new technology decelerates as penetration increases.
In contrast, growth in global EV unit sales accelerated from 60% in 2013 to an estimated 100%+ in 2021.

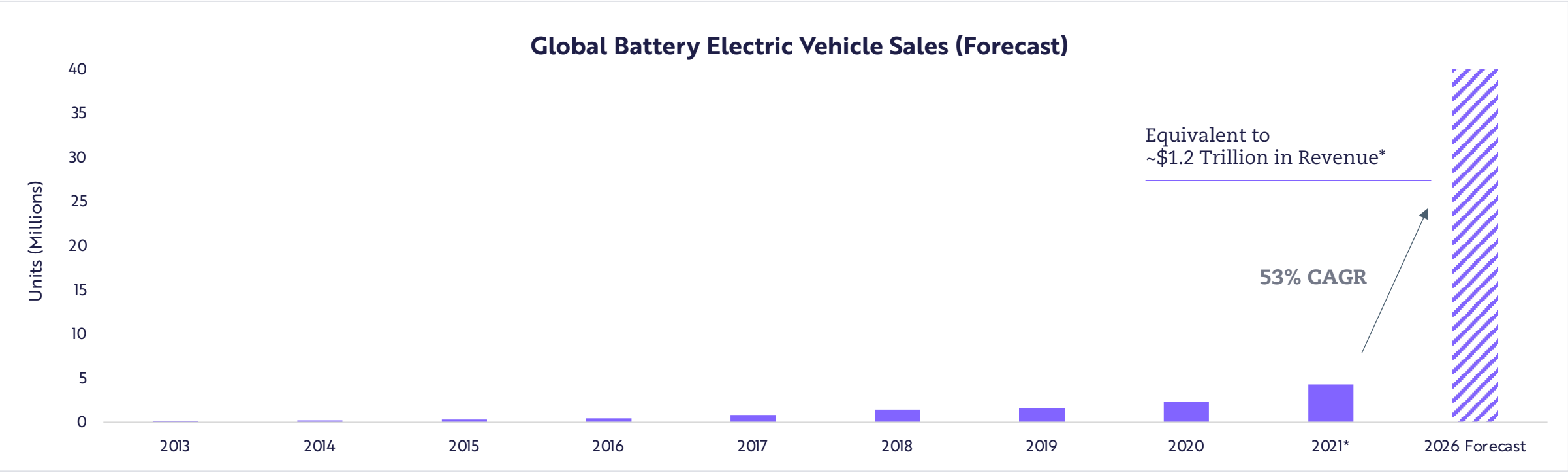




Forecasts are inherently limited and cannot be relied upon. | For informational purposes only and should not be considered investment advice, or a recommendation to buy, sell or hold any particular security.
Source: ARK Investment Management LLC, 2021. For right chart: data from Evvolumes.com

If Traditional Automakers Navigate The Shift From Gas-Powered Vehicles Successfully, EV Sales Could Scale 8-Fold From 4.8 Million to 40 Million During The Next Five Years.

ARK expects that sales of smaller, cheaper "neighborhood electric vehicles" will take off by 2026.



*Note: This assumes a $30,000 ASP.
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Source: ARK Investment Management LLC, 2021. Data from: Evvolumes.com

ARK INVEST

Autonomous Ride-Hailing

Driving Unprecedented Economic Productivity

Research by Tasha Keeney, ARK Analyst

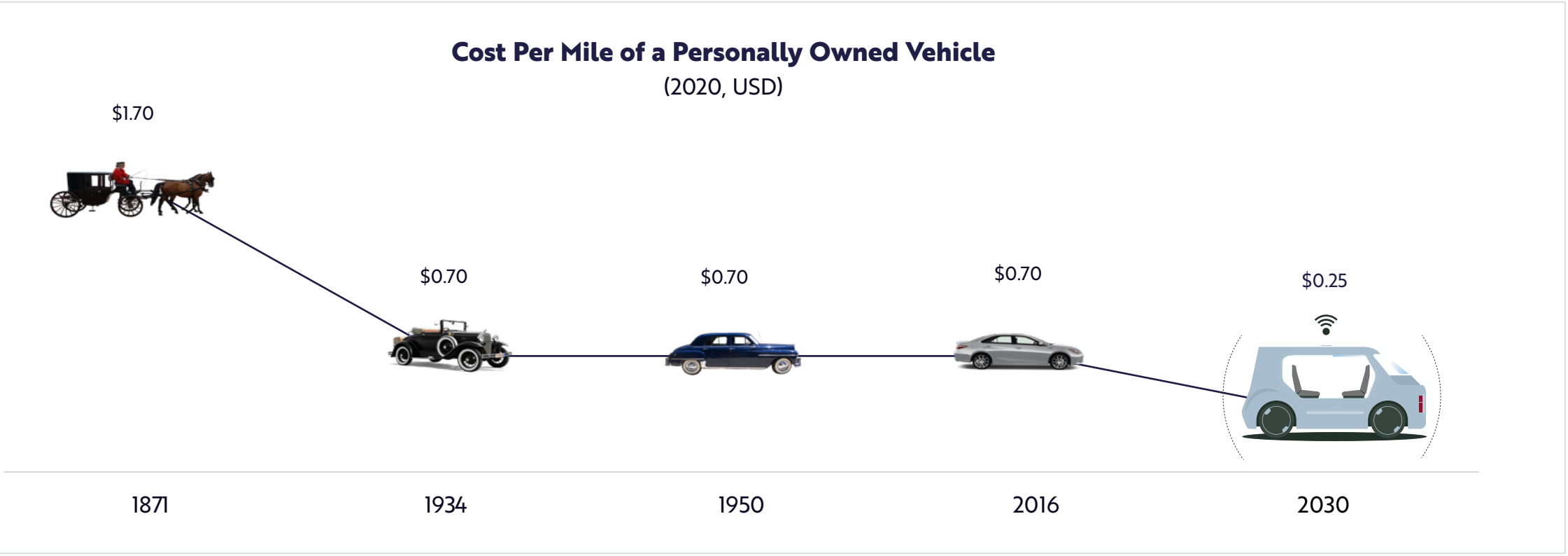
We believe autonomous ride-hailing will reduce the cost of mobility to one-eighth the average cost of ride-hail today, spurring widespread adoption and unleashing unprecedented economic productivity.

ARK's research suggests that autonomous ride-hailing platforms will add roughly $26 trillion to global GDP and $2 trillion in profits per year by 2030. For perspective, global GDP approached $89 trillion in 2021.[1]

[1] Estimate based on data sourced from "GDP (Current US$)." Data, https://data.worldbank.org/indicator/NY.GDP.MKTP.CD and "The Global Economic Outlook in Five Charts." World Bank Blogs, https://blogs.worldbank.org/voices/global-economic-outlook-five-charts-1. Forecasts are inherently limited and cannot be relied upon.

Autonomous Ride-Hail Is Likely To Be Extremely Affordable

Adjusted for inflation, the cost of owning and operating a personal car has not changed since the Model T rolled off the first assembly line. ARK estimates that, at scale, autonomous taxis could cost consumers as little as $0.25 per mile, spurring widespread adoption.



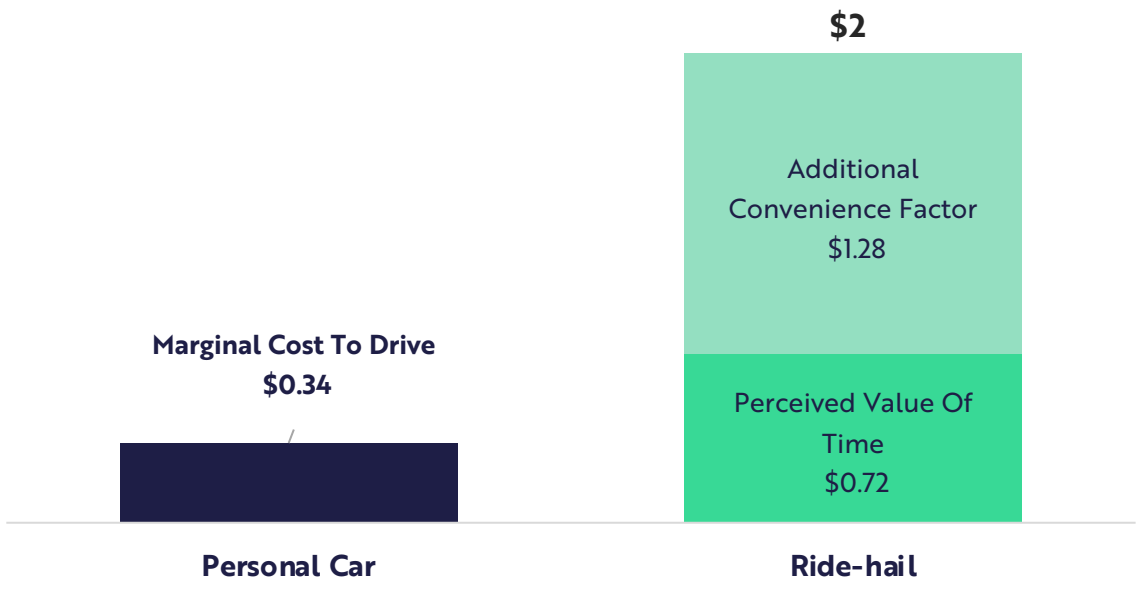
Forecasts are inherently limited and cannot be relied upon. | For informational purposes only and should not be considered investment advice, or a recommendation to buy, sell or hold any particular security.
Source: ARK Investment Management LLC, 2021; Morton Salt Company Records, American Automobile Association (AAA).

Autonomous Ride-Hail Is Likely To Win Share Of Miles Traveled, Even From Car Owners

ARK's research suggests that consumers value the time they spent driving in the $0.60 - $1.10 per mile range. On average, they value time in work-related travel more highly than non-work travel.

Today, consumers pay $2 per mile on average for ride-hail, significantly more than the marginal cost of driving a personal car and the perceived value of their time.

ARK's research suggests that the value consumers place on their time and on convenience will support prices for autonomous ride-hail higher than our estimated price floor of 25 cents per mile. We expect tiers of service to emerge at different price levels.

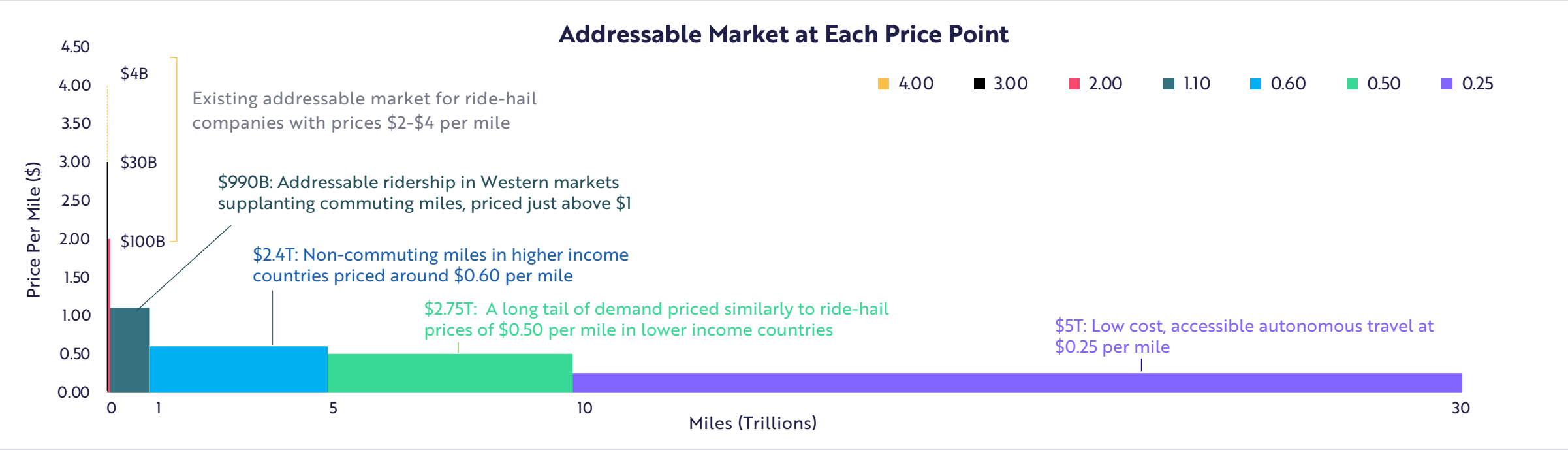


Note: The marginal cost to drive includes insurance, fuel, maintenance, and tires, and excludes all other fixed vehicle costs. Our $0.70 per mile cost to drive includes these fixed costs.

Sources: ARK Investment Management LLC, Revised Departmental Guidance 2016 - Transportation. https://www.transportation.gov/sites/dot.gov/files/docs/2016%20Revised%20Value%20of%20a%20Statistical%20Life%20Guidance.pdf. , Summary of Travel Trends - National Household Travel Survey. https://nhts.ornl.gov/assets/2017_nhts_summary_travel_trends.pdf. Goldszmidt, Ariel, et al. "The Value of Time in the United States: Estimates from Nationwide Natural Field Experiments." EconPapers, 2020, https://econpapers.repec.org/RePEc:feb:natura:00720. "Average Hourly Earnings for Private Payrolls Increased 3.1 Percent for Year Ended January 2020." U.S. Bureau of Labor Statistics, U.S. Bureau of Labor Statistics, 11 Feb. 2020, https://www.bls.gov/opub/ted/2020/average-hourly-earnings-for-private-payrolls-increased-3-point-1-percent-for-year-ended-january-2020.htm. Your Driving Costs 2021. AAA, https://newsroom.aaa.com/wp-content/uploads/2021/08/2021-YDC-Brochure-Live.pdf.

Ride-Hail Demand Is Likely To Create An $11 Trillion Addressable Market

At $0.25 cents per mile, autonomous ride-hail could attract a wider population than ride-hail serves today.
ARK also expects significant demand at higher price points based on the value that consumers place on their time.

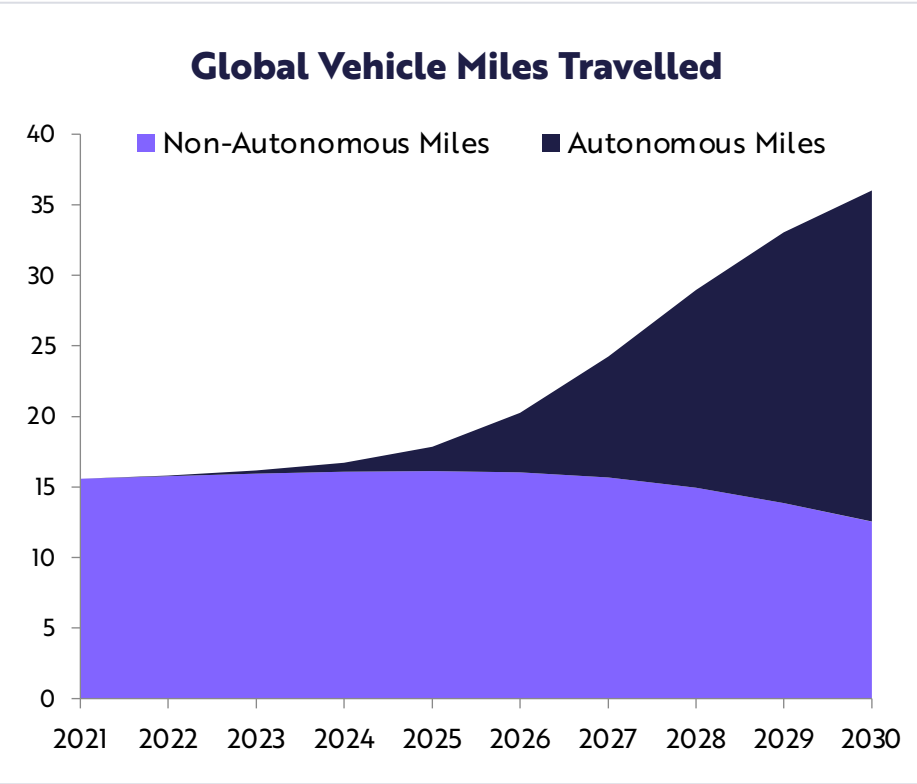


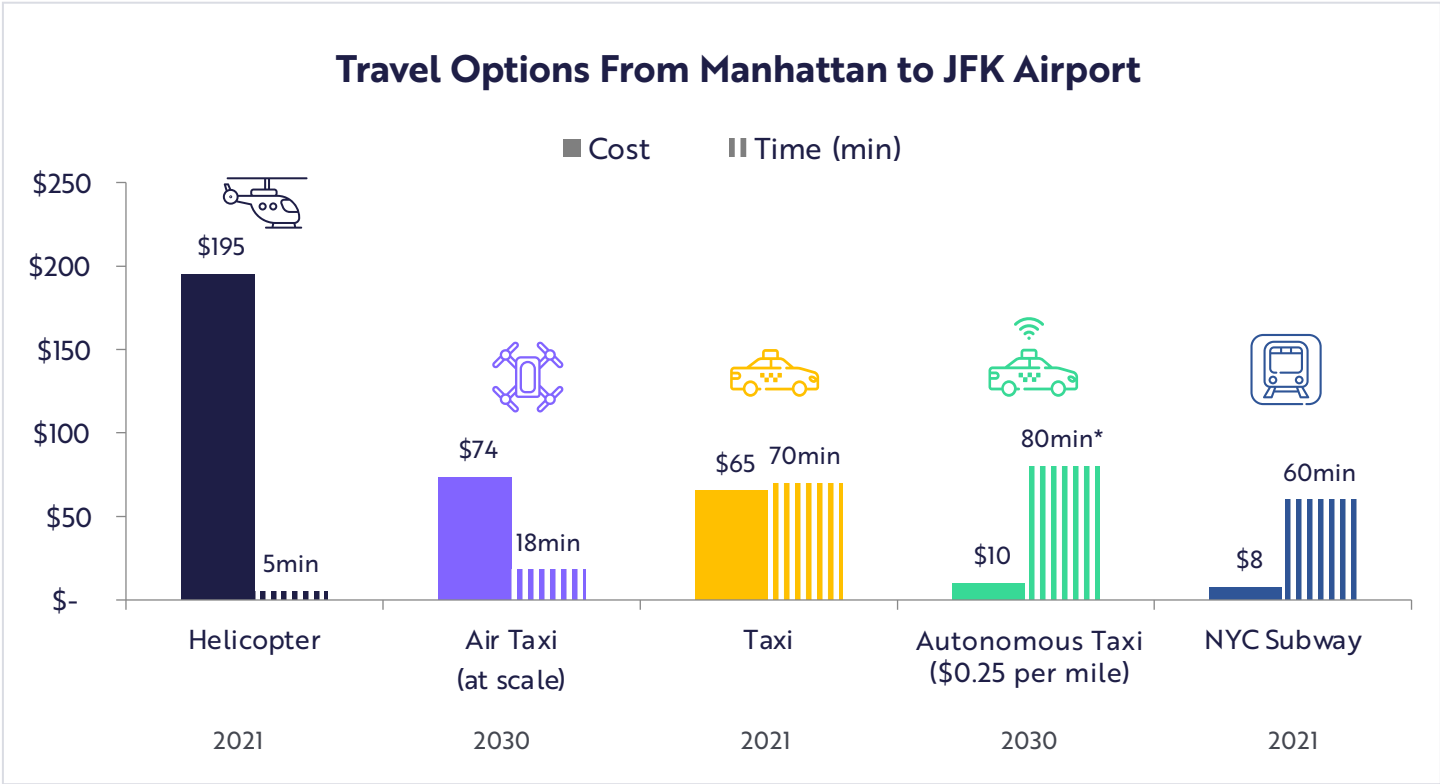
Note: Each rectangle represents a pocket of demand for a specific number of miles (its width) at a particular price point (its height measured in price per mile).

Forecasts are inherently limited and cannot be relied upon. | For informational purposes only and should not be considered investment advice, or a recommendation to buy, sell or hold any particular security.
Source: ARK Investment Management LLC, Revised Departmental Guidance 2016 - Transportation. https://www.transportation.gov/sites/dot.gov/files/docs/2016%20Revised%20Value%20of%20a%20Statistical%20Life%20Guidance.pdf. , Summary of Travel Trends - National Household Travel Survey. https://nhts.ornl.gov/assets/2017_nhts_summary_travel_trends.pdf. Goldszmidt, Ariel, et al. "The Value of Time in the United States: Estimates from Nationwide Natural Field Experiments." EconPapers, 2020, https://econpapers.repec.org/RePEc:feb:natura:00720. "Average Hourly Earnings for Private Payrolls Increased 3.1 Percent for Year Ended January 2020." U.S. Bureau of Labor Statistics, U.S. Bureau of Labor Statistics, 11 Feb. 2020, https://www.bls.gov/opub/ted/2020/average-hourly-earnings-for-private-payrolls-increased-3-point-1-percent-for-year-ended-january-2020.htm. Your Driving Costs 2021. AAA, https://newsroom.aaa.com/wp-content/uploads/2021/08/2021-YDC-Brochure-Live.pdf.

Autonomous Mobility Could Increase Traffic And Create An Opportunity For Air Taxis

Priced at $0.25 per mile, autonomous ride-hail is likely to expand the customer base and increase traffic congestion significantly. Our research suggests that autonomous air taxis will offer faster travel options at price points roughly the same as ground taxis today.

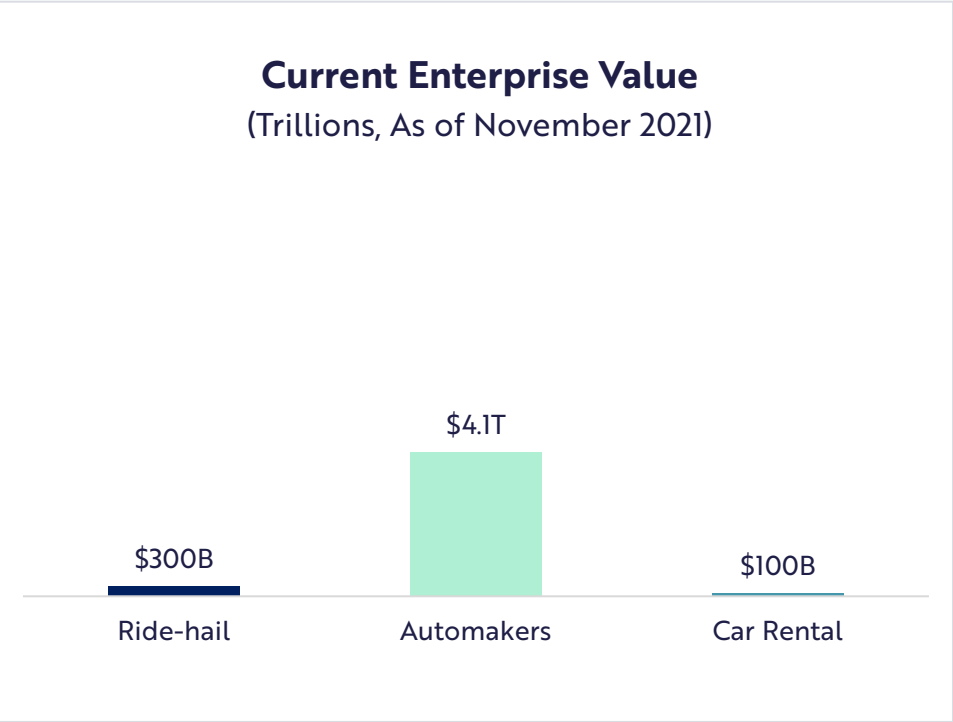


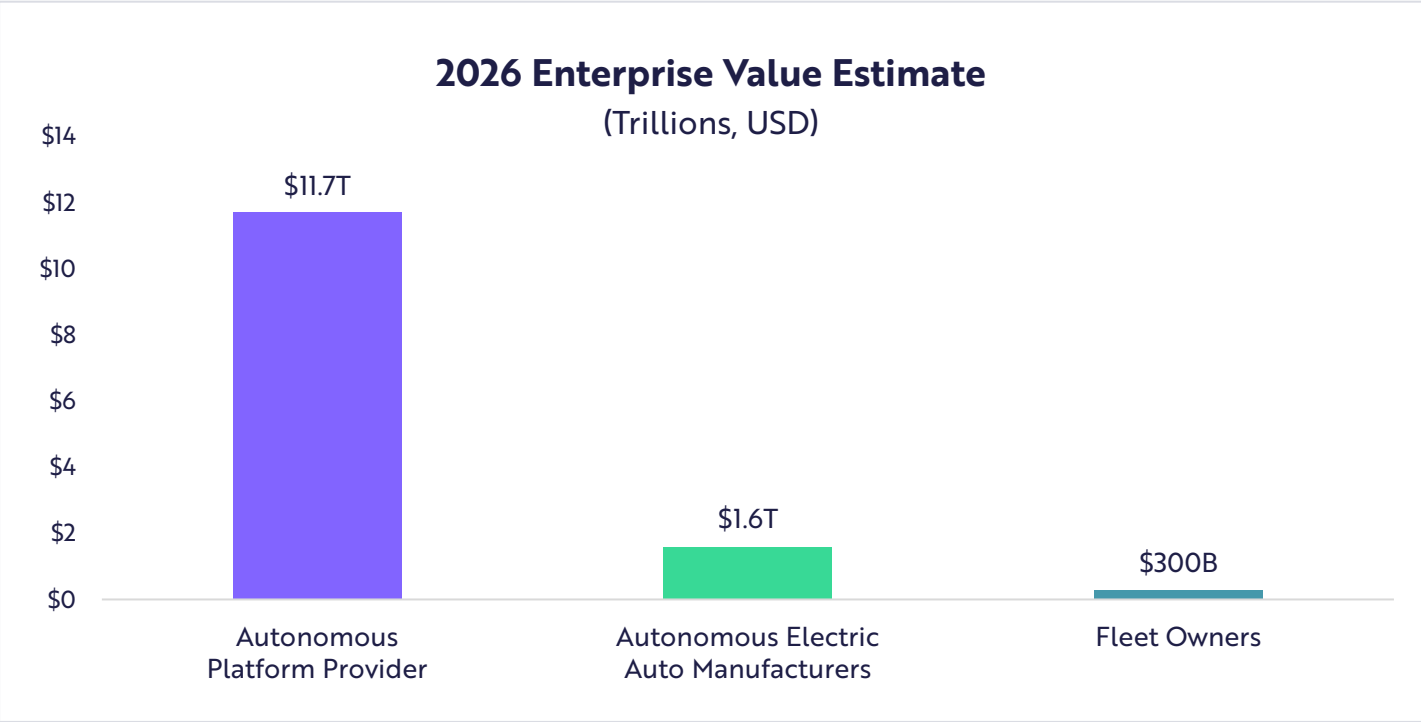


*ARK expects traffic to increase with autonomous vehicles.
Forecasts are inherently limited and cannot be relied upon. | For informational purposes only and should not be considered investment advice, or a recommendation to buy, sell or hold any particular security.
Source: ARK Investment Management LLC, 2021.

By 2026, The Enterprise Value Of Autonomous Ride-Hail Platforms Could Be Much Higher Than That Of Automakers Today

According to our research, companies that own the autonomous technology stack could dominate enterprise values in the future auto ecosystem. We believe that many of today's ride-hail, auto manufacturing, and car rental companies will not survive the transition.



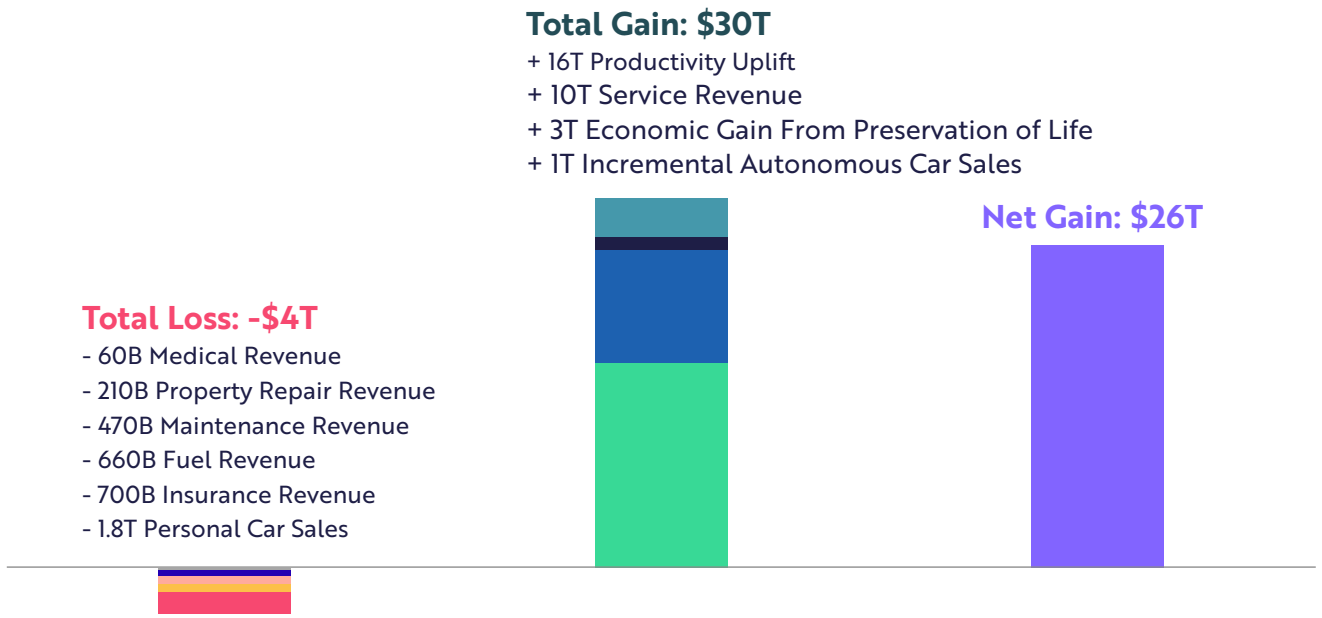


Note: Assumes a multiple of 19X earnings for platform providers, 13X for autonomous electric auto manufacturers, and 5X for fleet owners | Note: Values are rounded to the nearest billion.

Source: ARK Investment Management LLC, 2021, data from CapitalIQ

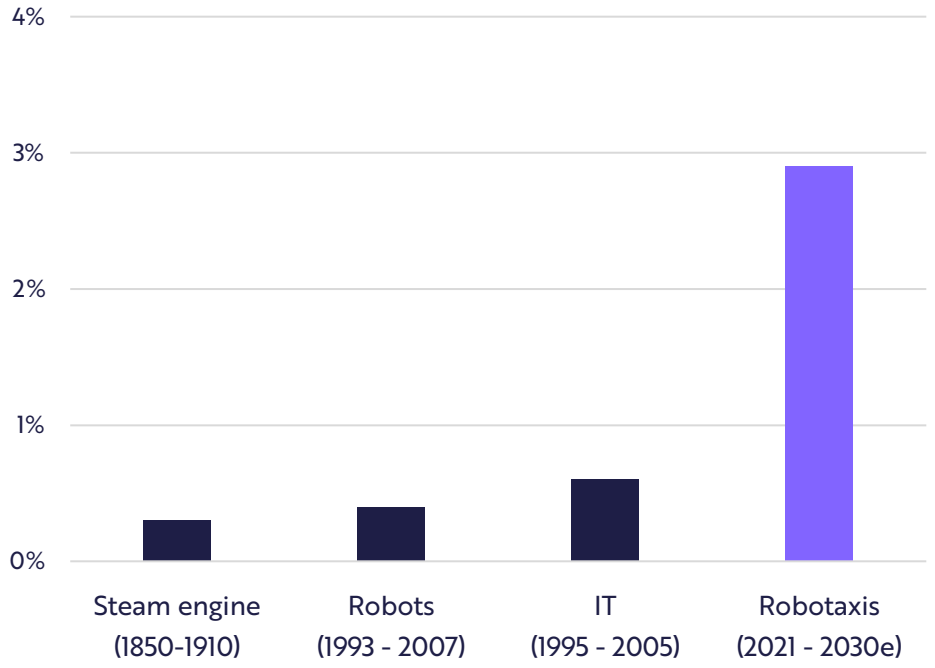
Autonomous Ride-Hail Could Have More Economic Impact Than Any Innovation In History, Adding Roughly $26 Trillion To Global GDP By 2030

Potential Global Economic Impact of Autonomous Ride-Hail, 2030 Forecast



Annual GDP Productivity Impact

(Percentage points)



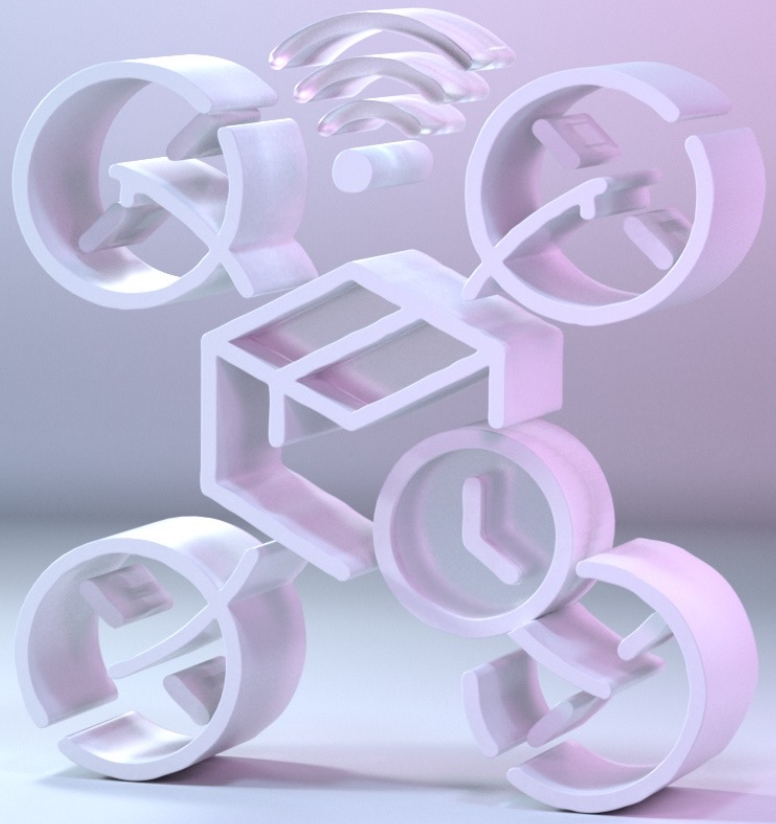
Notes: IT = Information Technology. Figures in graphs are rounded.
Forecasts are inherently limited and cannot be relied upon. | For informational purposes only and should not be considered investment advice, or a recommendation to buy, sell or hold any particular security.
Sources: ARK Investment Management LLC, 2021; Bughin, Jacques, et al. MGI Notes from the AI Frontier Modeling the Impact of AI ...McKinsey, 2018 https://www.mckinsey.com/~/media/McKinsey/Featured%20Insights/Artificial%20Intelligence/Notes%20from%20the%20frontier%20Modeling%20the%20impact%20of%20AI%20on%20the%20world%20economy/MGI-Notes-from-the-AI-frontier-Modeling-the-impact-of-AI-on-the-world-economy-September-2018.ashx.

ARK INVEST

Autonomous Logistics

Reshaping the Global Supply Chain

Research by Tasha Keeney, ARK Analyst

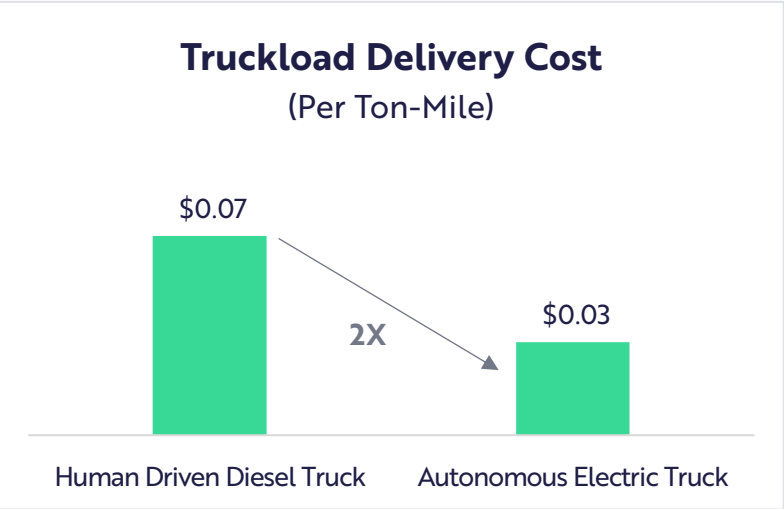


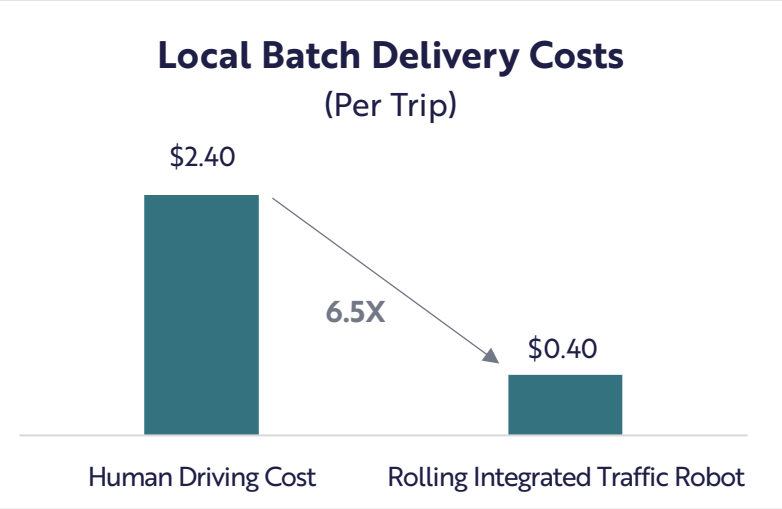
Autonomous logistics, including trucks, drones, and rolling robots, could lower costs and offer faster and more convenient delivery of goods.

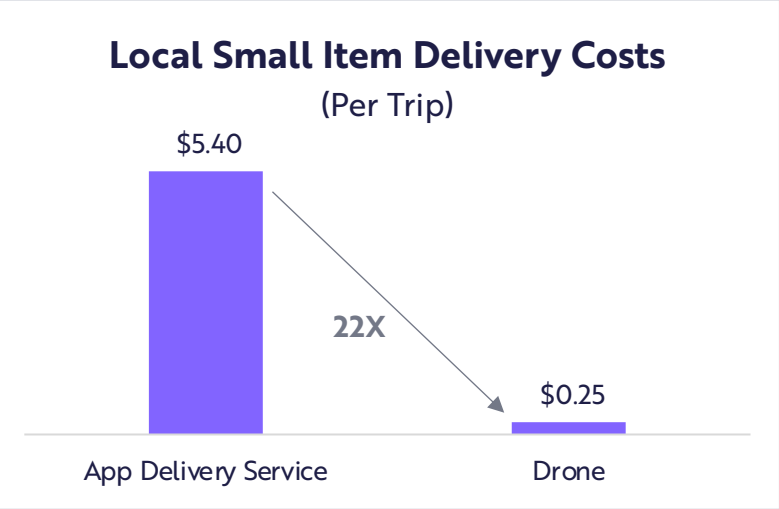
ARK believes that autonomous logistics revenues could scale from nil today to $900 billion in 2030.

Autonomous Vehicles That Roll And Fly Could Lower Costs Across The Supply Chain

According to our research, autonomous vehicles will operate at higher utilization rates than human-in-the-loop systems, creating more cost-effective delivery systems, particularly for small volumes in the last mile.







Autonomous electric trucks should benefit from higher utilization and lower maintenance and labor costs than human-driven diesel trucks.

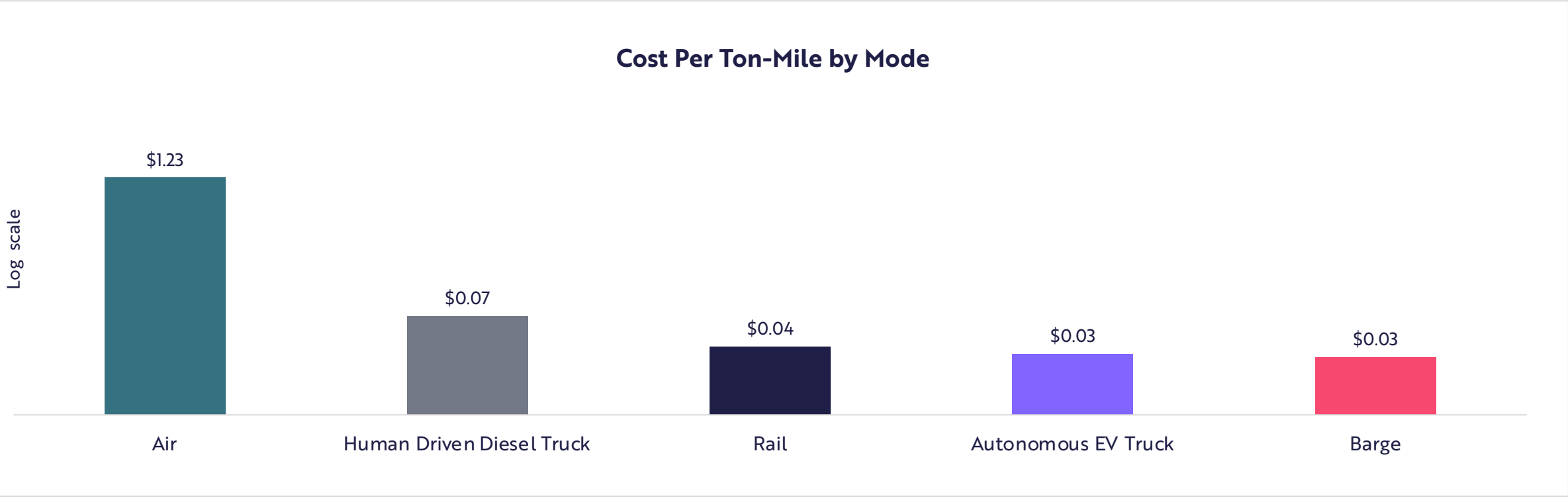
Rolling grocery robots should enable inexpensive and convenient delivery, reshaping consumer shopping habits.

Autonomous drones are likely to deliver a substantial share of e-commerce parcels and online food sales.

Source: ARK Investment Management LLC, 2021, Source: ARK Investment Management LLC, 2021; "National Statistics and Maps." National Statistics and Maps - FHWA Freight Management and Operations, https://www.ops.fhwa.dot.gov/Freight/freight_analysis/nat_freight_stats/index.htm. ; "Average Truck Speeds." Energy.gov, https://energy.gov/eere/vehicles/fact-671-april-18-2011-average-truck-speeds. ; Fleet Owner. https://www.fleetowner.com/. ; Ferguson, Dave. "Introducing R2, Nuro's next Generation Self-Driving Vehicle." Medium, Nuro, 6 Feb. 2020, https://medium.com/nuro/introducing-r2-nuros-next-generation-self-driving-vehicle-a9974ff6c2e0. ; "Most U.S. Households Do Their Main Grocery Shopping at Supermarkets and Supercenters Regardless of Income." USDA ERS - Most U.S. Households Do Their Main Grocery Shopping at Supermarkets and Supercenters Regardless of Income, https://www.ers.usda.gov/amber-waves/2015/august/most-us-households-do-their-main-grocery-shopping-at-supermarkets-and-supercenters-regardless-of-income/. ; Your Driving Costs. https://newsroom.aaa.com/wp-content/uploads/2021/08/2021-YDC-Brochure-Live.pdf. ; "Phantom 2 Vision+ v3.0." DJI Store - Official Store for DJI Drones, Gimbals and Accessories (United States), https://store.dji.com/product/phantom-2-vision-plus. ; Chen, Brian X. "Up to 91% More Expensive: How Delivery Apps Eat up Your Budget." The New York Times, The New York Times, 26 Feb. 2020, https://www.nytimes.com/2020/02/26/technology/personaltech/ubereats-doordash-postmates-grubhub-review.html.

Autonomous Trucks Are Likely To Be More Cost Effective Than Rail, Expanding Their Addressable Market

Door-to-door trucks should offer significant speed advantages over rail and take share from intermodal transport.



Note: Intermodal transport is the movement of freight by two or more modes of transportation.

Forecasts are inherently limited and cannot be relied upon. | For informational purposes only and should not be considered investment advice, or a recommendation to buy, sell or hold any particular security.
Source: ARK Investment Management LLC, 2021, data sources: "National Statistics and Maps." National Statistics and Maps - FHWA Freight Management and Operations, https://www.ops.fhwa.dot.gov/Freight/freight_analysis/nat_freight_stats/index.htm. ; "Table 3-21: Average Freight Revenue per Ton-Mile (Current Cents)." Bureau of Transportation Statistics, https://www.bts.gov/archive/publications/national_transportation_statistics/table_03_21. ; "Average Freight Revenue per Ton-Mile." Average Freight Revenue per Ton-Mile | Bureau of Transportation Statistics, https://www.bts.gov/content/average-freight-revenue-ton-mile.

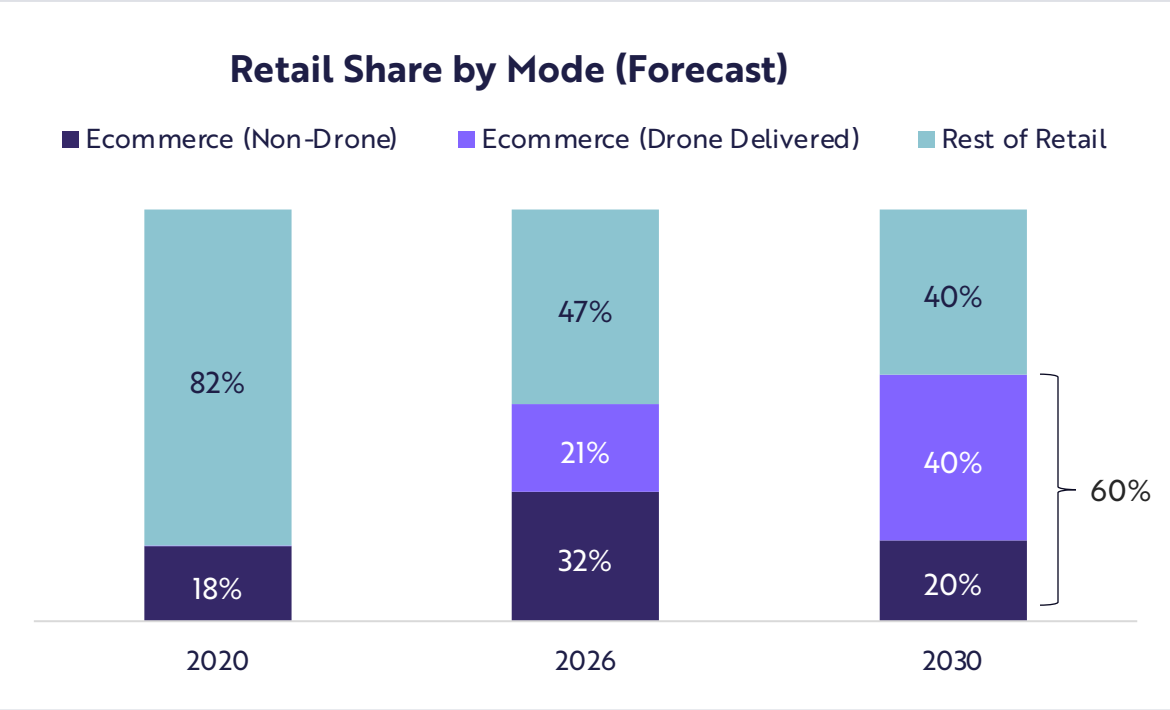
Robot Grocery Delivery Could Lower Costs By 6X And Convert Unpaid Labor Into Paid Services

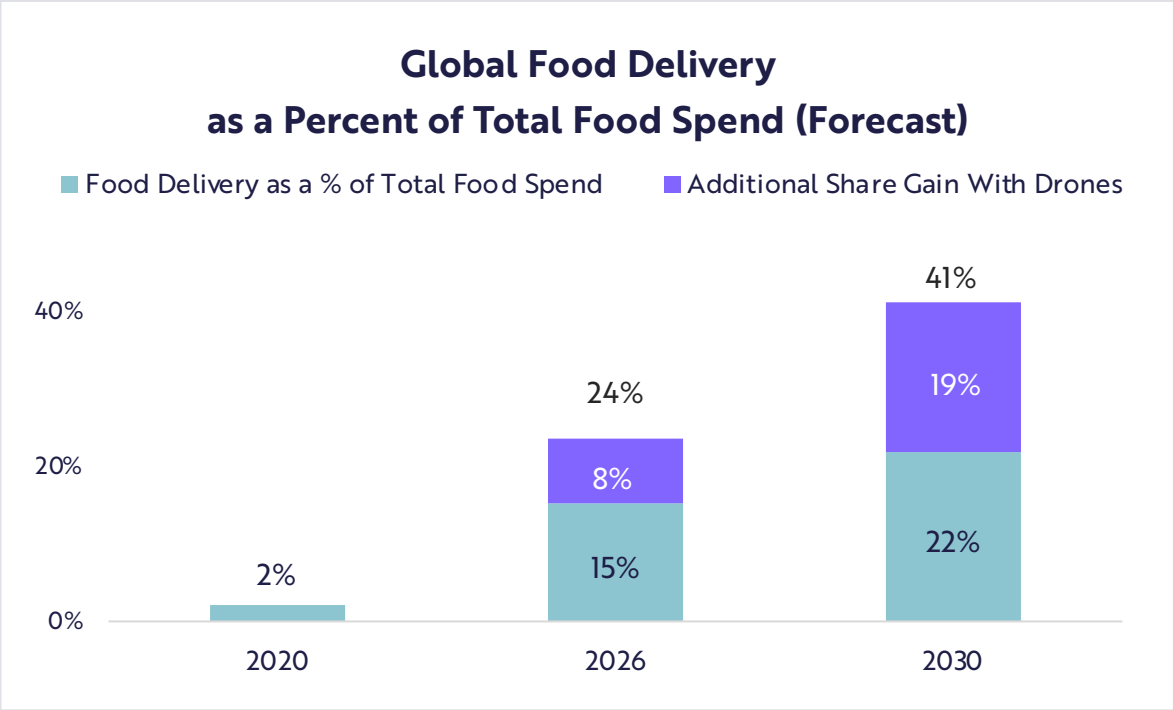
ARK estimates that, as electric robots replace gas-powered cars, robot grocery delivery could convert roughly $40 billion of unpaid labor into paid services and erase $6 billion in gasoline demand. In other words, robot delivery could prevent roughly 18 million metric tons of CO_2 emissions per year, the equivalent of taking 4 million gas-powered cars off the road.

Forecasts are inherently limited and cannot be relied upon. | For informational purposes only and should not be considered investment advice, or a recommendation to buy, sell or hold any particular security.
Sources: ARK Investment Management LLC, 2021; "FMI's 2019 U.S. Grocery Shopper Trends Examines Personalized Grocery Shopping." FMI, 18 June 2019, https://www.fmi.org/newsroom/news-archive/view/2019/06/18/fmi-s-2019-u.s.-grocery-shopper-trends-examines-personalized-grocery-shopping. "U.S. Energy Information Administration - EIA - Independent Statistics and Analysis." Environment - U.S. Energy Information Administration (EIA) - U.S. Energy Information Administration (EIA), https://www.eia.gov/environment/emissions/co2_vol_mass.php.

Drones Could Deliver The Majority Of E-Commerce Sales And Push Food Delivery Into An S-Curve

Drone delivery should be more efficient and cost-effective in transporting goods and meals, especially for suburban and rural residents, increasing food delivery as a percent of total spending on food.

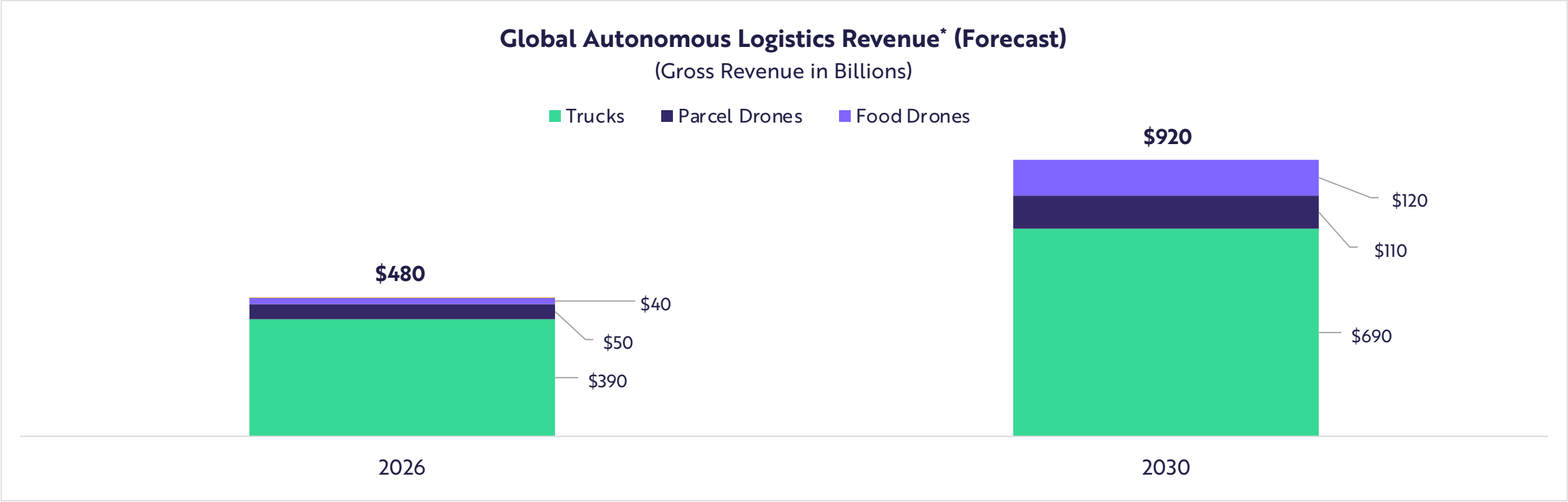




Sources: ARK Investment Management LLC, 2021. "Pitney Bowes Parcel Shipping Index." *Pitney Bowes*, https://www.pitneybowes.com/us/shipping-index.html#. , "Data and Research on Digital for Business Professionals." *Insider Intelligence*, http://www.emarketer.com/. , *Euromonitor*, https://www.euromonitor.com/. , "Food Expenditure Series." *USDA ERS - Food Expenditure Series*, https://www.ers.usda.gov/data-products/food-expenditure-series/.

Autonomous Logistics Revenues Could Scale From Nil Today To More Than $900 Billion in 2030

ARK's research suggests that autonomous logistics will reshape the global supply chain completely, giving consumers faster and more convenient ways to receive goods. Shopping habits and homes could be reshaped in ways that will save consumers time and money.



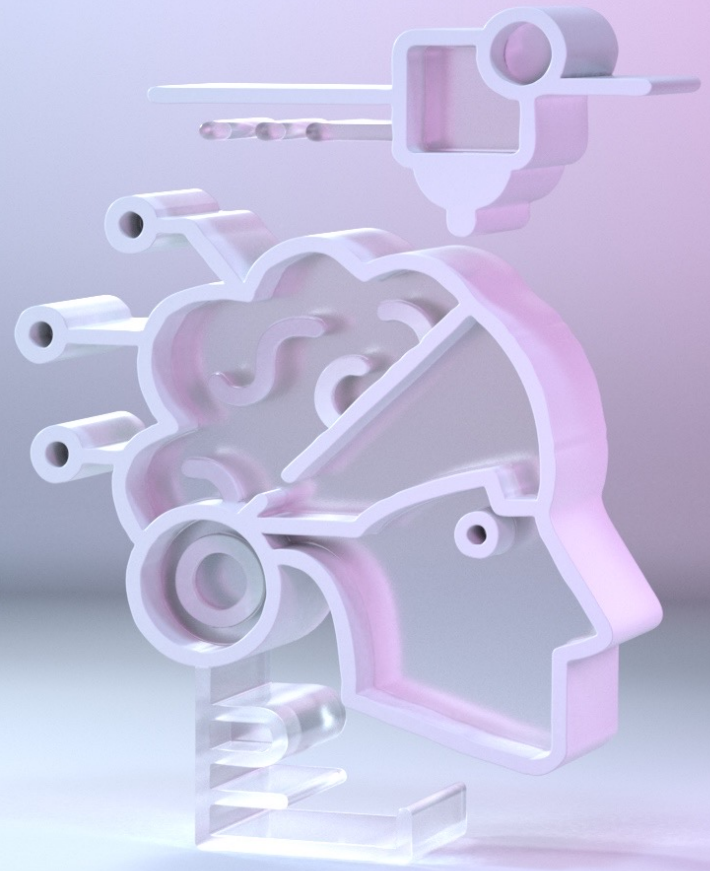
*ARK's research on the market size and timeline for rolling robots is still evolving and has not been included in our estimate for autonomous logistics global revenues by 2030.
Forecasts are inherently limited and cannot be relied upon. | For informational purposes only and should not be considered investment advice, or a recommendation to buy, sell or hold any particular security.
Source: ARK Investment Management LLC, 2021

ARK INVEST

3D Printing & Robotics

The Next Generation of Manufacturing

Research by Tasha Keeney and Sam Korus, ARK Analysts

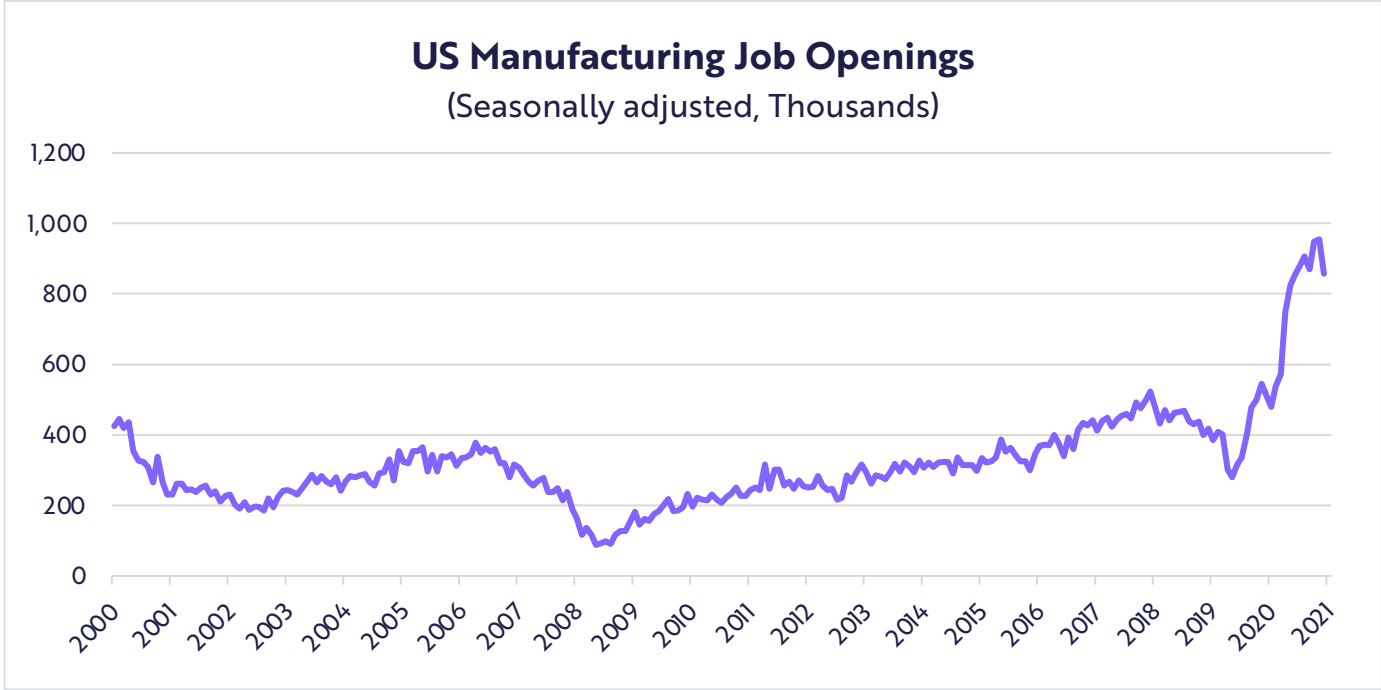


3D printing and adaptable robots shorten supply chain footprints, allow for digital inventory, and reduce materials waste while cutting costs and time-to-production.

Supply chain shocks and labor shortages should accelerate the use of 3D printing and robotics. ARK estimates that 3D printing and robotics could scale at a 56% annual rate, from nearly $70 billion in public enterprise value in 2020 to over $6 trillion in 2030.

Supply Chain And Labor Force Disruptions Could Accelerate The Adoption Of Automated Manufacturing

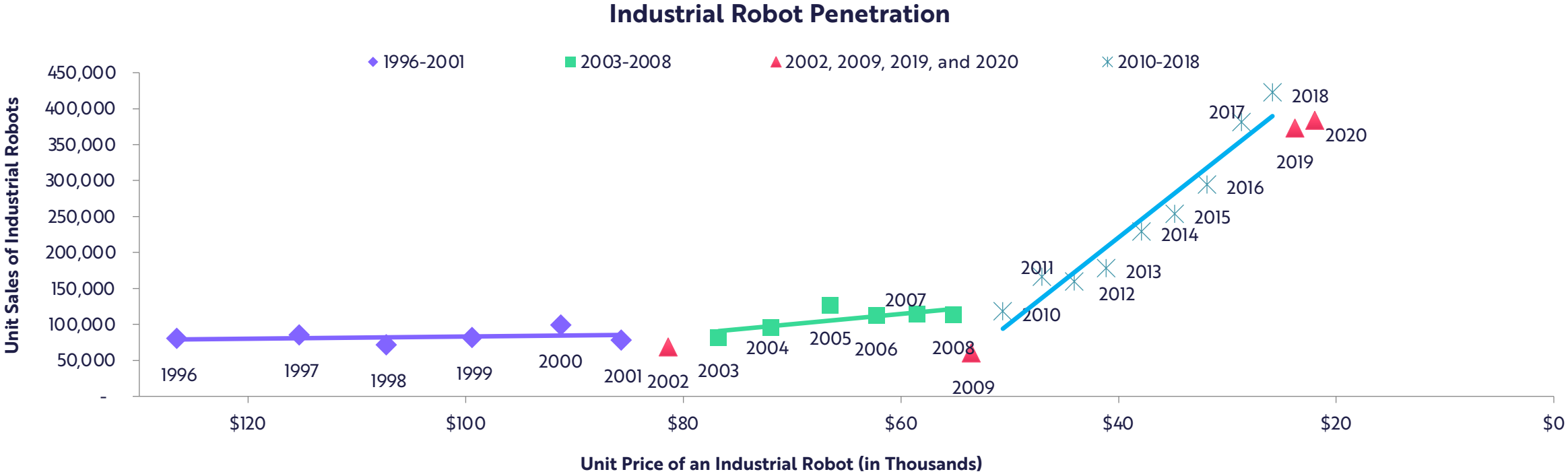
We believe that 3D printing and robotics will increase manufacturers' flexibility and responsiveness to demand spikes, supply chain fluctuations, and labor shortages.



Forecasts are inherently limited and cannot be relied upon. | For informational purposes only and should not be considered investment advice, or a recommendation to buy, sell or hold any particular security.
Sources: Williamson, Chris. "Understanding ... PMI Suppliers' Delivery Times: A Widely Used Indicator of Supply Delays, Capacity Constraints and Price Pressures." *IHS Markit*, IHS Markit, 21 July 2021, https://ihsmarkit.com/research-analysis/understanding--pmi-suppliers-delivery-times-a-widely-used-indicator-of-supply-delays-capacity-constraints-and-price-pressures-Jul21.html. "Jolts News Releases." *U.S. Bureau of Labor Statistics*, U.S. Bureau of Labor Statistics, https://www.bls.gov/jlt/.

The Adoption Of Automation Typically Accelerates In Crises

The adoption of industrial robots accelerated after the 2002 dot-com bust and again after the 2008-2009 crisis. In response to the China/US trade conflict in 2019 and supply chain bottlenecks during 2020 and 2021, the penetration of industrial robots probably will gain more momentum.



Sources: ARK Investment Management LLC, 2021; Executive Summary World Robotics 2021 Industrial Robots. https://ifr.org/img/worldrobotics/Executive_Summary_WR_Industrial_Robots_2021.pdf.

3D Printing Enables Digital Inventory And Distributed Manufacturing, Adding Flexibility To Supply Chains

Manufacturers can produce 3D-printed parts on demand, in single or small batch runs, **eliminating the need to hold physical inventory** of spare and low volume parts.

A “digital inventory” of part designs and printing instructions can combine with physical inventory of raw material, **shrinking the footprint of warehouses.**

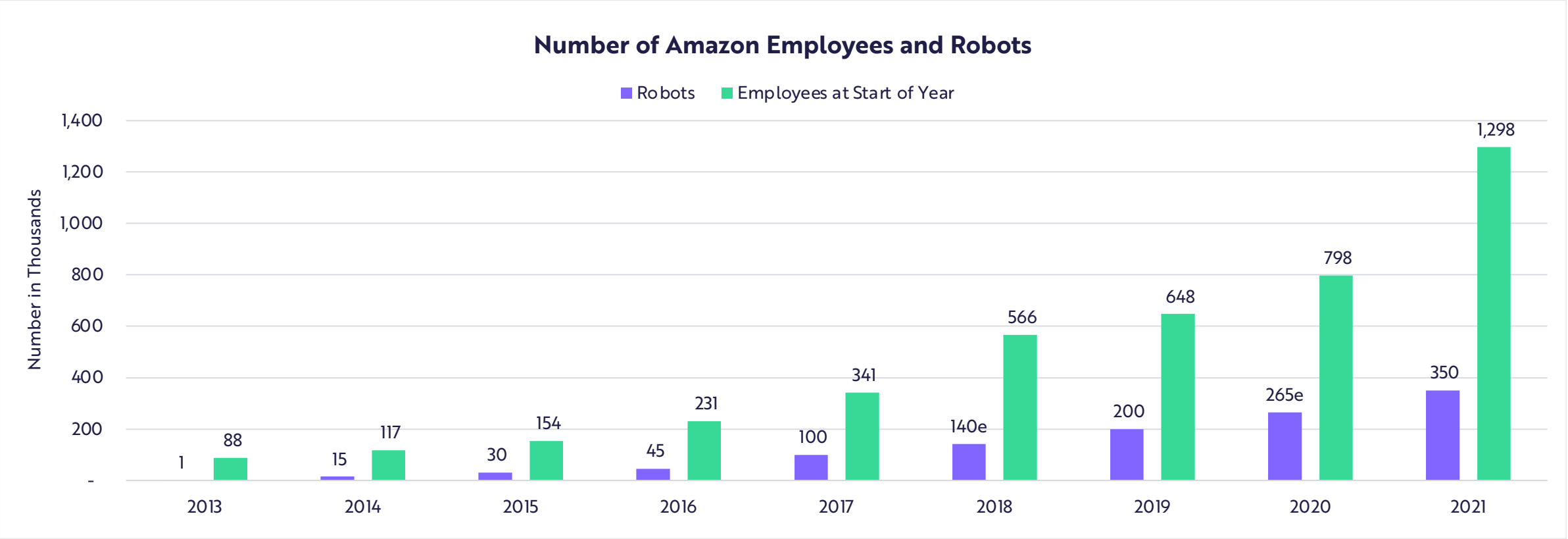
Manufacturers can place 3D printers near the destinations of final products, **reducing supply chain footprints and shipping costs.**

3D Printing allows manufacturers to vertically integrate, reducing reliance on outside suppliers while **saving time and cost.**

Sources: “Schubert: A Digital Warehouse for on-Demand Manufacturing.” Ultimaker.com, https://ultimaker.com/learn/schubert-a-digital-warehouse-for-on-demand-manufacturing.

Automation Is Consistent With Job Growth

Amazon deployed its first 200,000 robots over seven years and another 150,000 in just two years. During those nine years, Amazon's workforce grew nearly fifteen-fold. Despite the elimination of retail positions, we believe automation will enable new products and services that otherwise would not exist, on balance increasing the demand for labor.



Forecasts are inherently limited and cannot be relied upon. | For informational purposes only and should not be considered investment advice, or a recommendation to buy, sell or hold any particular security.
Source: ARK Investment Management LLC, 2021; Amazon 10-ks.

3D Printing Enhances Product Performance And Accelerates The Pace Of Innovation

According to our research, as electric vehicle sales scale from nearly 5 million to roughly 40 million over the next five years, auto manufacturers will have to adapt by retooling and reinventing manufacturing lines. 3D printing allows for rapid prototyping, the elimination of tooling, a reduction in the number of parts, and faster time-to-market.

At its main plant in Germany, **Volkswagen** reduced the weight of an A-pillar by 74%, cut part count by 2/3, and plans to produce 100,000 3D-printed parts per year by 2025.

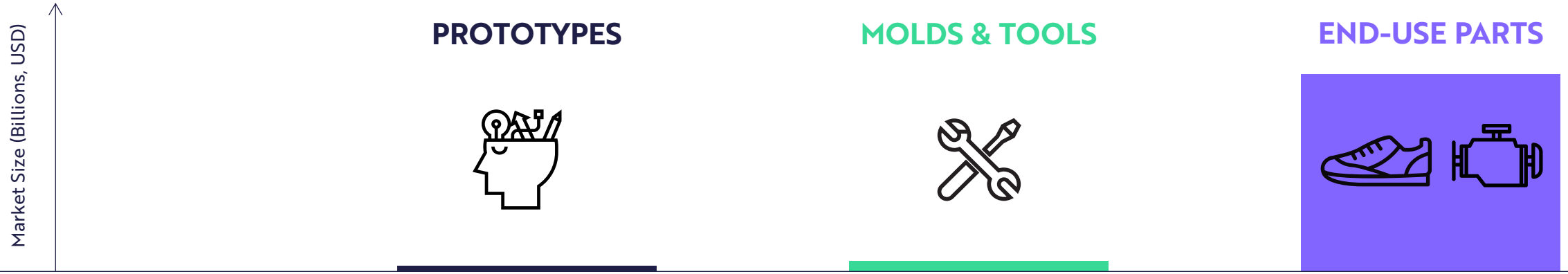
Dana, the auto supplier, used 3D printing to achieve a 10x improvement in speed.

Moving from outsourcing to 3D printing its parts in house, **Nissan** reduced costs by 200x and wait times for parts by 7X.

Sources: "Open Visual Engineering Platform: Bionic Design of Volkswagen Golf A-Pillar." ELISE, 10 Dec. 2020, https://www.elise.de/industries/automotive/volkswagen-a-pillar/. Markforged Investor Presentation. https://static.markforged.com/downloads/Markforged+Investor+Presentation.pdf. "Nissan Accelerates Assembly, Lowers Costs with 3D Printing." Control Engineering, 8 July 2021, https://www.controleng.com/articles/nissan-accelerates-assembly-lowers-costs-with-3d-printing/. "Volkswagen Plans to Use New 3D Printing Process in Vehicle Production in the Years Ahead." Volkswagen Newsroom, https://www.volkswagen-newsroom.com/en/press-releases/volkswagen-plans-to-use-new-3d-printing-process-in-vehicle-production-in-the-years-ahead-7269.

3D Printing Still Is In Its Infancy

ARK's research indicates that 3D printing for end-use parts is the next frontier.

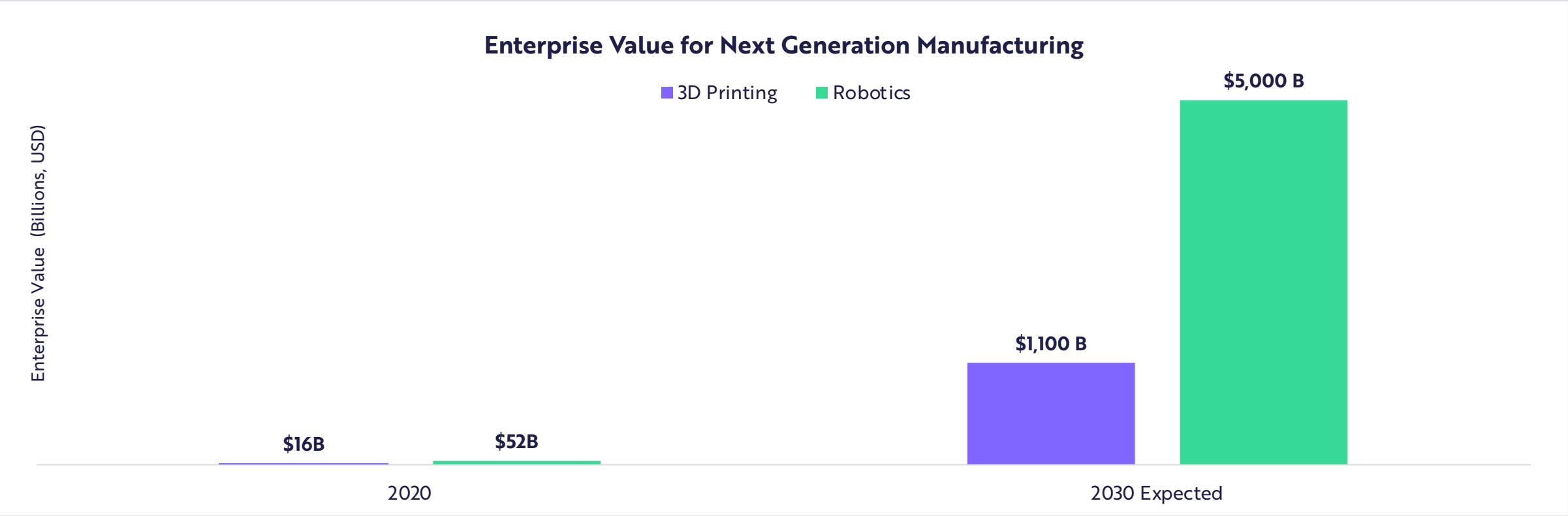


Market Potential:	$12.5 Billion	$30 Billion	$490 Billion
Current Penetration	60-70%	6%	1%
Expected Penetration 2026	**80-90%**	**~30%**	**~20%**
First Applications	*1980's*	*1990's*	*Early 2000's*

Forecasts are inherently limited and cannot be relied upon. | For informational purposes only and should not be considered investment advice, or a recommendation to buy, sell or hold any particular security.
Source: ARK Investment Management LLC, 2021, data sourced from; McKinsey; Stratasys; "3D Printing History." AV Plastics, 14 June 2018, https://arkinv.st/2TC57H1

ARK Expects The Enterprise Value For 3D Printing And Robotics To Scale From $70 Billion Today To Over $6 Trillion By 2030.

3D printing and robotics offer cost reductions, tools for innovation, and increased productivity. Supply chain and labor disruptions could accelerate the shift to next generation manufacturing technologies.



Note: Enterprise value calculation assumes a 5% cash flow yield for 3D Printing and Robotics. Robotics does not include home-based robotics.
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Sources: ARK Investment Management LLC, 2021; CapitalIQ data

ARK INVEST

Orbital Aerospace

Enabling Global Connectivity

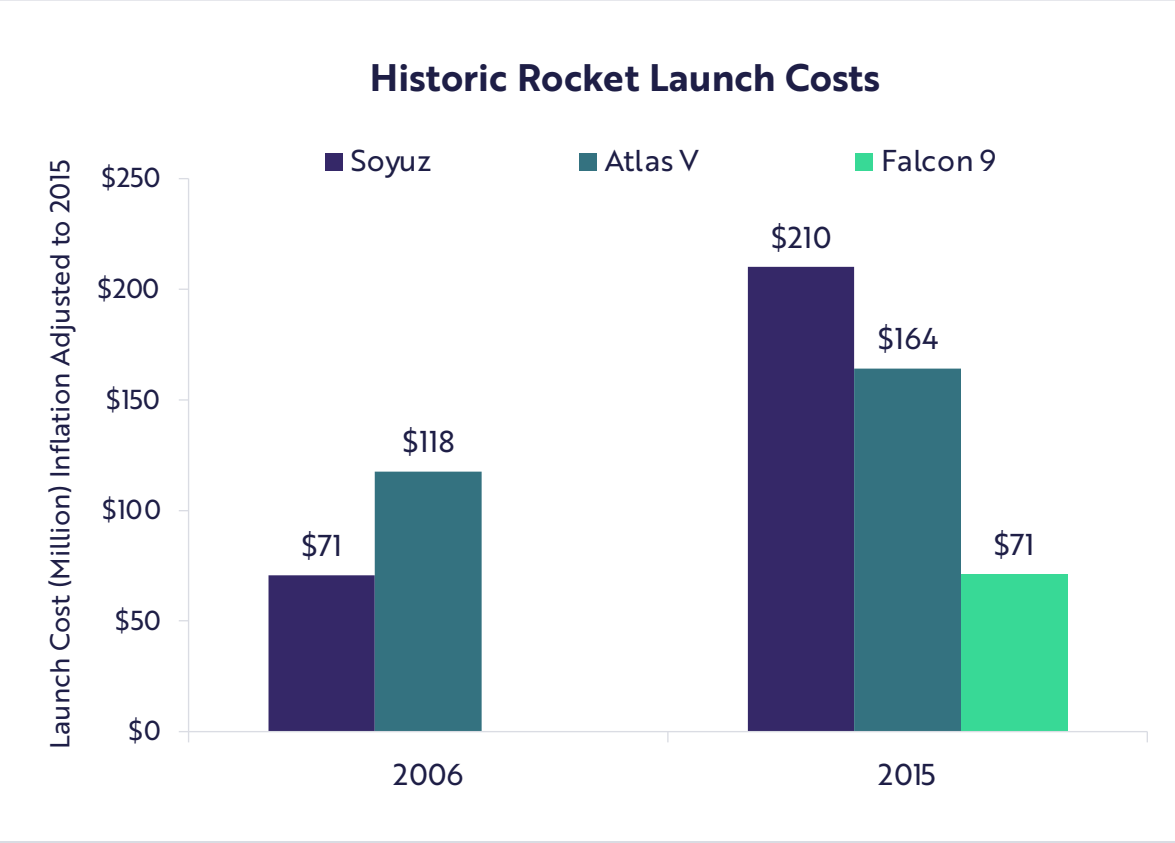
Research by Sam Korus, ARK Analyst

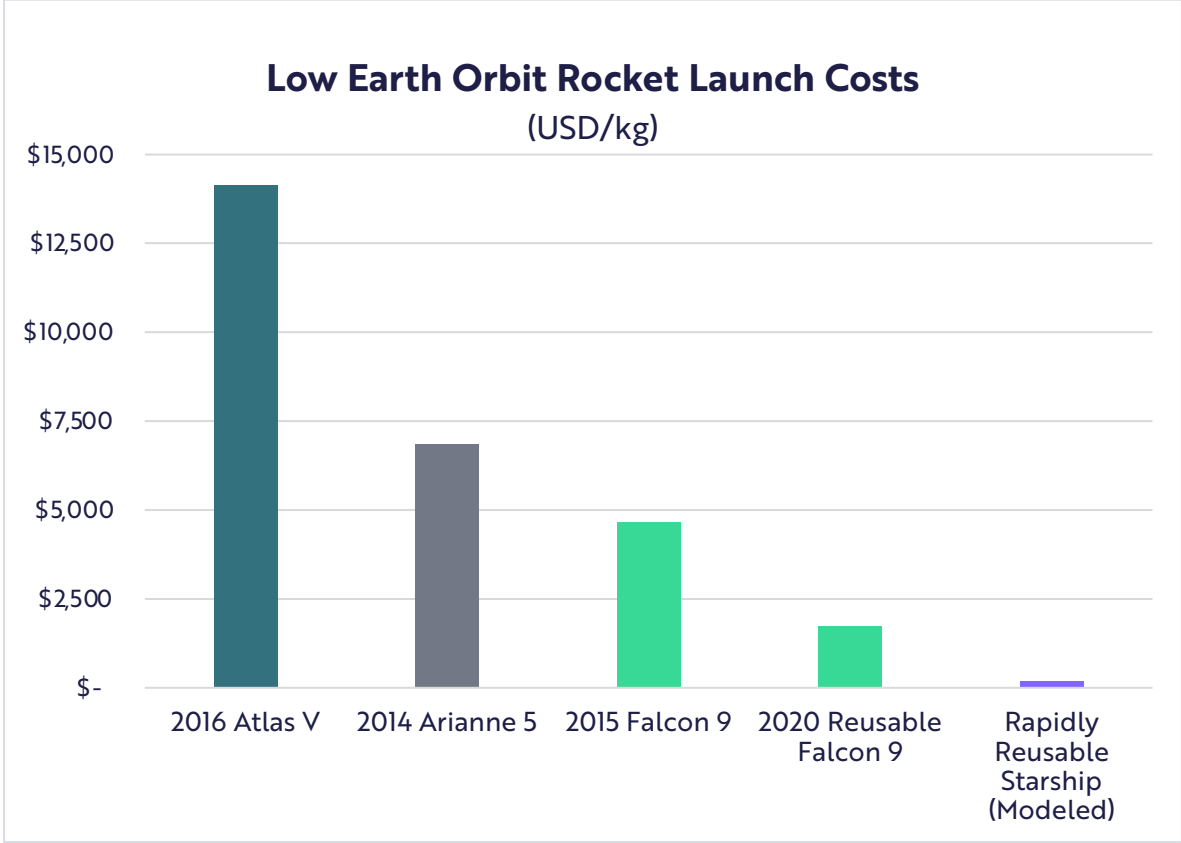
Aerospace costs are declining thanks to advancements in deep learning, mobile connectivity, sensors, 3D printing, and robotics. As a result, satellite launches and rocket landings are proliferating.

According to ARK's research, satellite broadband revenues could approach $10 billion per year in the US and $40 billion globally during the next 5-10 years. In addition, the hypersonic flight market could scale from nil to $270 billion in annual revenues.

Rocket Reusability Should Lower Launch Costs By An Order Of Magnitude

SpaceX put an end to soaring launch costs with its Falcon 9 reusable rocket, flying the same booster 11 times.





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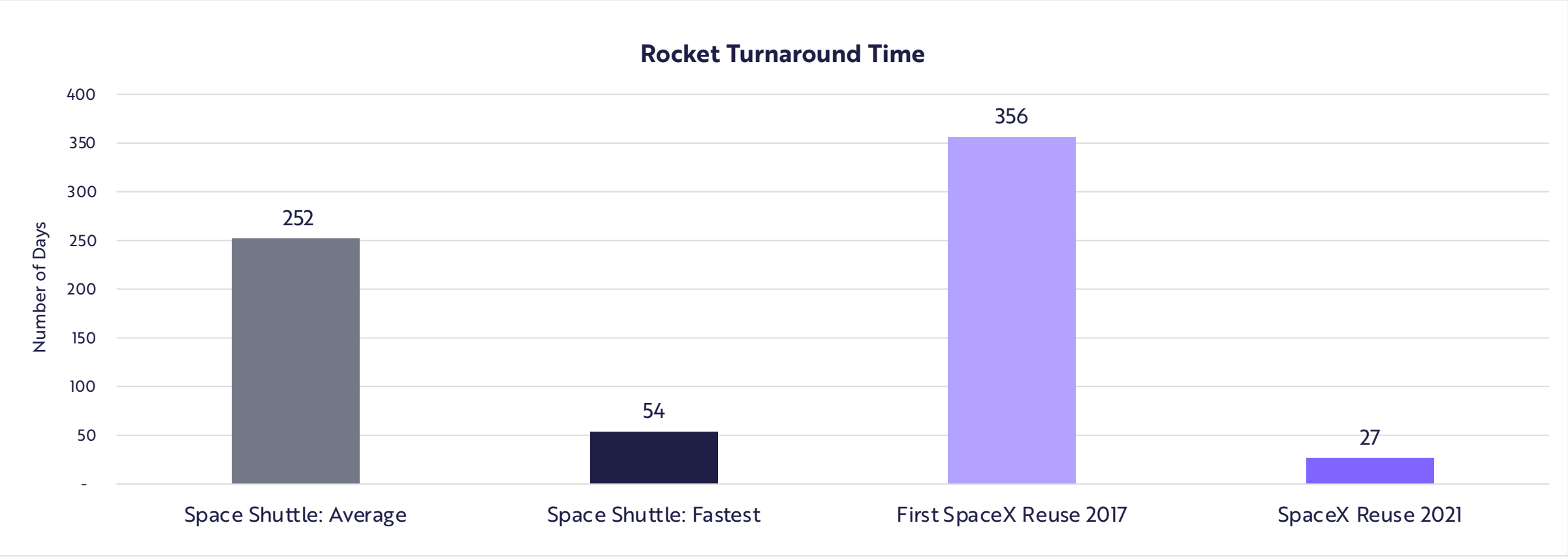
Source: ARK Investment Management LLC, 2021, http://spacenews.com/40006spacex-says-requirements-not-markup-make-government-missions-more-costly/, https://oig.nasa.gov/audits/reports/FY13/IG-13-019.pdf, http://spacenews.com/rising-engine-costs-uncertainty-drive-atlas-5-prices-nasa/, http://www.ulalaunch.com/faqs-launch-costs.aspx , http://www.spacex.com/about/capabilities, http://spacenews.com/rising-engine-costs-uncertainty-drive-atlas-5-prices-nasa/,

SpaceX Is Refurbishing Rockets In Record Time

In ARK's view, a crucial variable determining their cost declines will be the time in which rockets can be refurbished.



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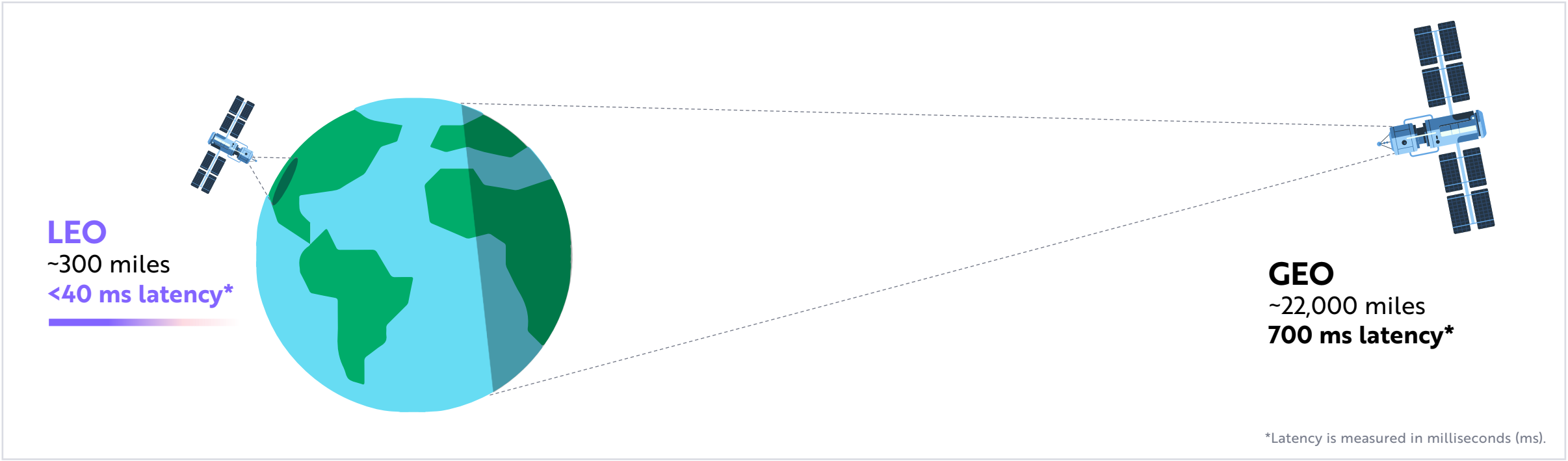
Source: ARK Investment Management LLC, 2021, https://www.reddit.com/r/spacex/wiki/cores#wiki_b1049, http://www.nasa.gov/pdf/537939main_ss-launches-080311.pdf

Lower Satellite Launch Costs Could Enable Continuous Global Coverage With Low Latency

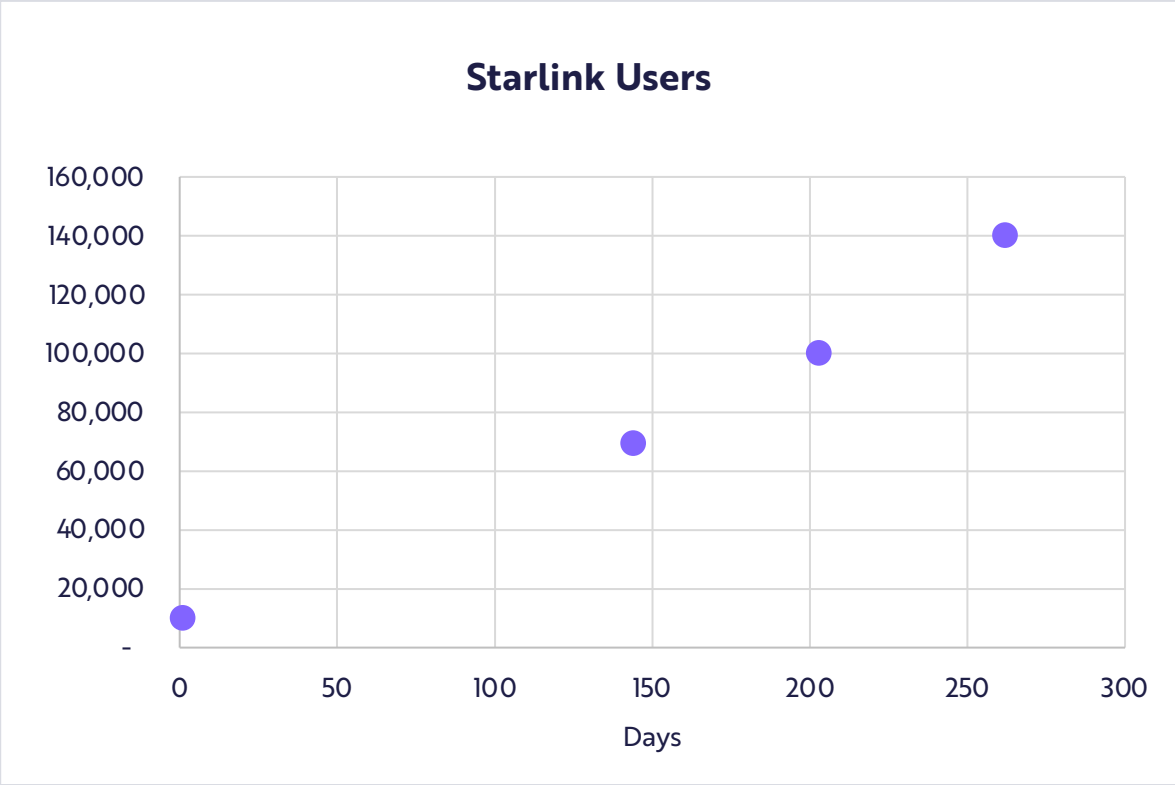
When satellites launched into geostationary orbit (GEO) offered global coverage, latency limited their ability to provide a compelling broadband internet offering. Today, companies including SpaceX, OneWeb, Amazon, and others are launching or have plans to launch thousands of low cost satellites into low earth orbit (LEO), enabling continuous global coverage with low latency.

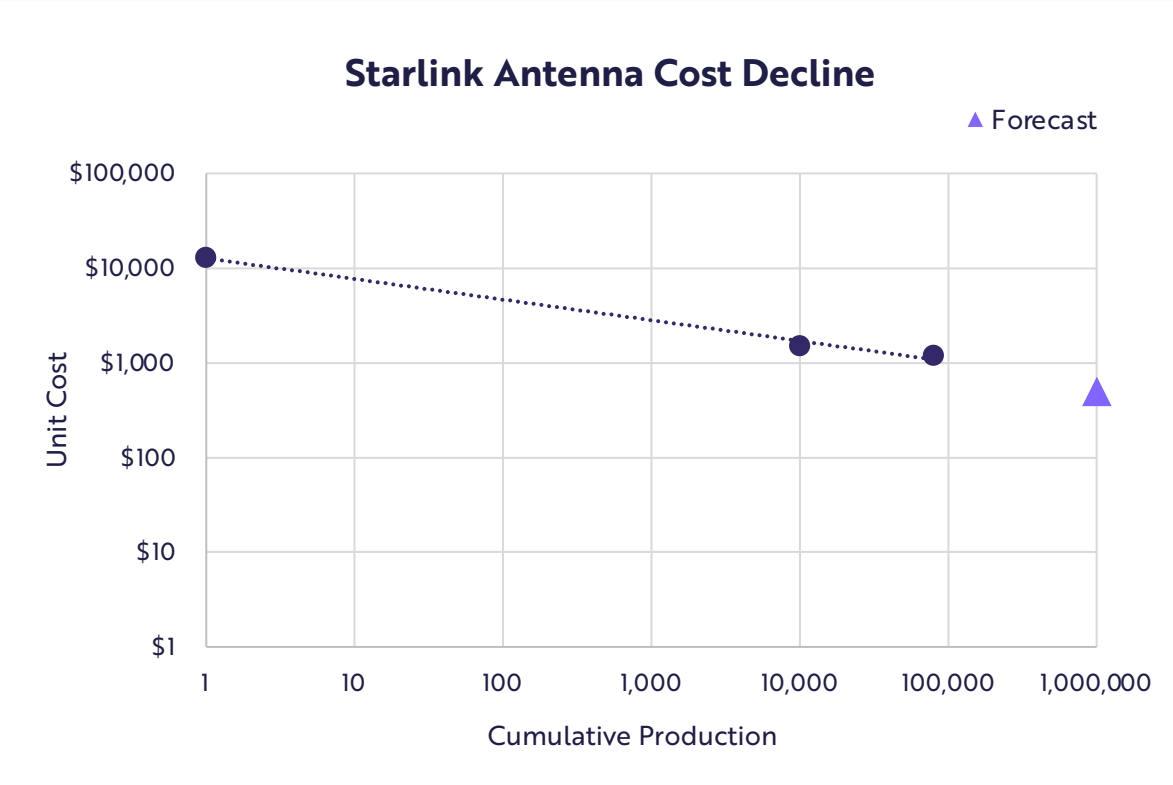


Source: ARK Investment Management LLC, 2020, based on data sourced from: "Satellites 101: LEO vs. GEO." Iridium Satellite Communications, 9 September 2018, www.iridium.com/blog/2018/09/11/satellites-101-leo-vs-geo/, Jon Brodkin Nov 2, 2020, 9:09 pm UTC. "SpaceX Starlink Users Provide First Impressions and Unboxing Pictures." Ars Technica, 2 Nov. 2020, arstechnica.com/information-technology/2020/11/spacex-starlink-beta-tester-takes-user-terminal-into-forest-gets-120mbps/?utm_social-type=owned.

Antenna Costs Could Drop Below $500 In The Next Few Years

Based on limited data, including our modeled adoption curve for Starlink users, ARK's research suggests that the cost of end user antennas could drop from roughly $1,000 today to $500 after cumulative production reaches one million units by the end of 2023.



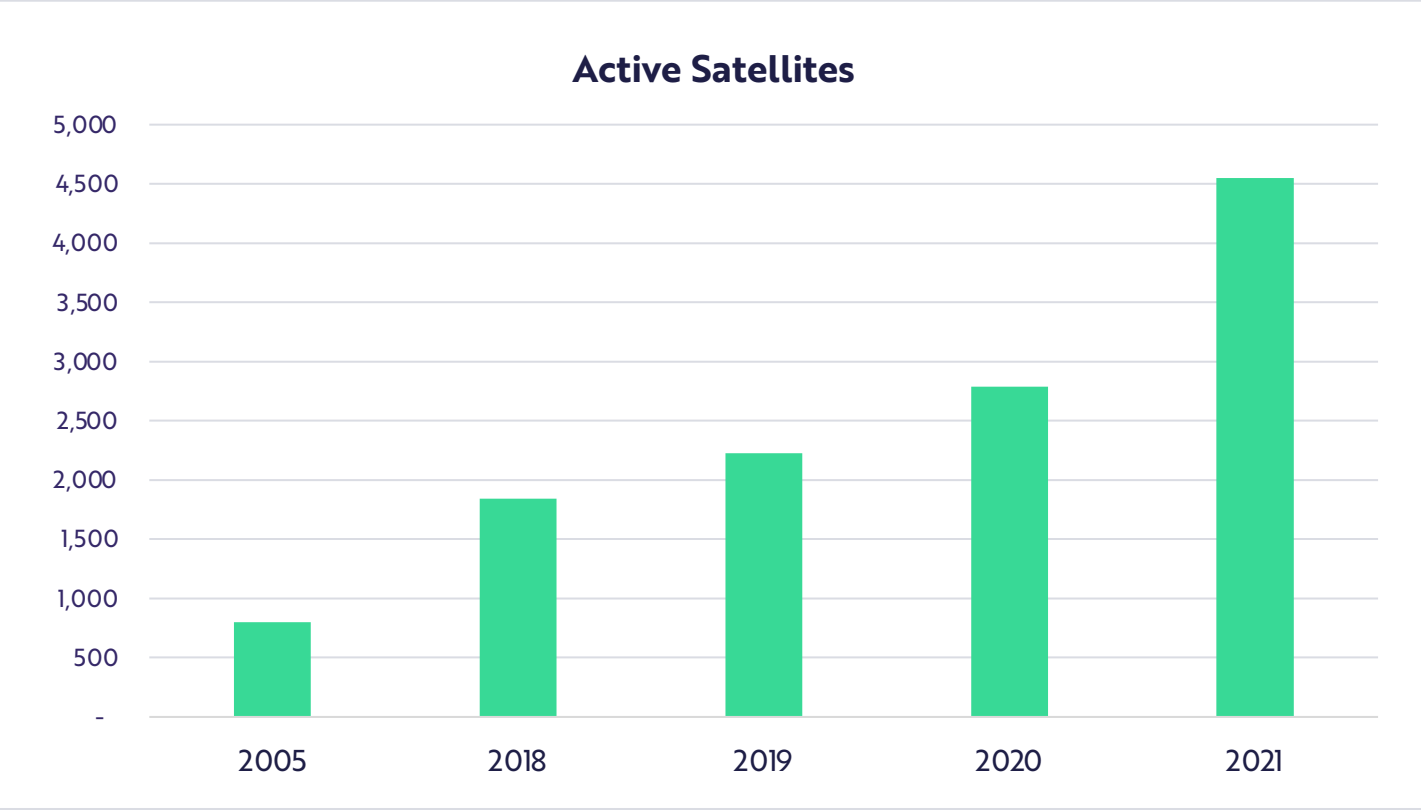


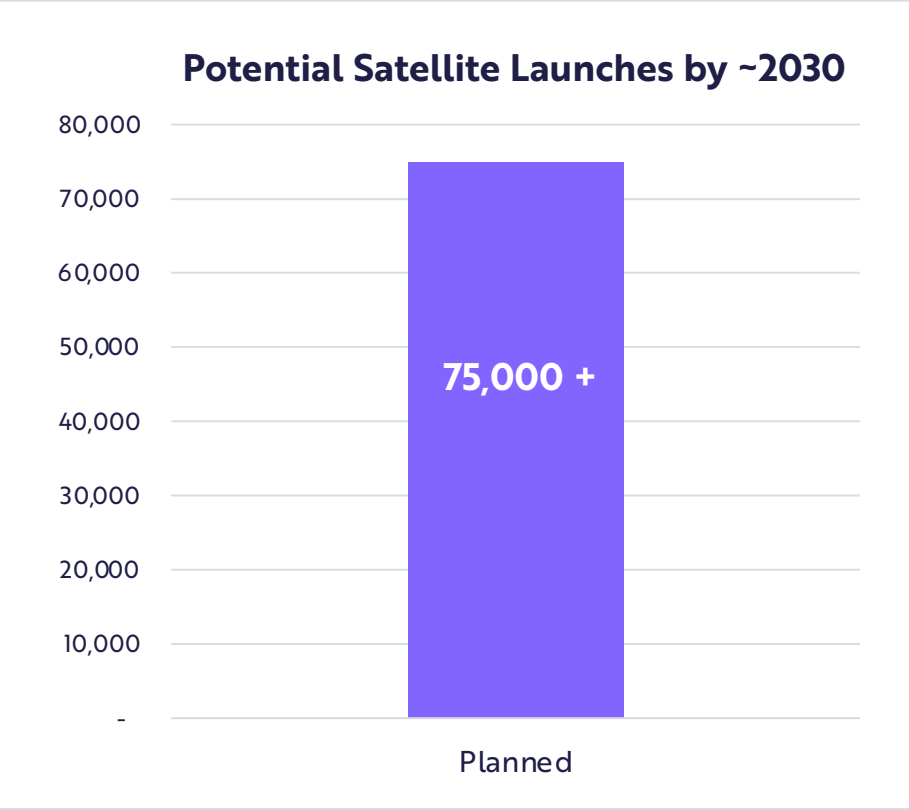
Note: ARK uses Starlink for its antenna cost decline model because it has the most satellites in orbit and the data is most readily available.

Source: ARK Investment Management LLC, 2021, https://twitter.com/elonmusk/status/1408558492009566214, https://twitter.com/elonmusk/status/1429907171639103489, https://www.tesmanian.com/blogs/tesmanian-blog/starlink-users-fcc, https://www.engadget.com/spacex-starlink-satellite-internet-global-coverage-084815155.html, https://twitter.com/Free_Space/status/1379459724991725571

Cost Declines Should Increase The Number of Satellites Scheduled For Orbit

The number of active satellites orbiting earth nearly doubled during in the past two years. According to public data, companies are planning an order of magnitude increase in satellite launches during the next ten years. The 75,000 of launches planned by 2030 has tripled since last year.





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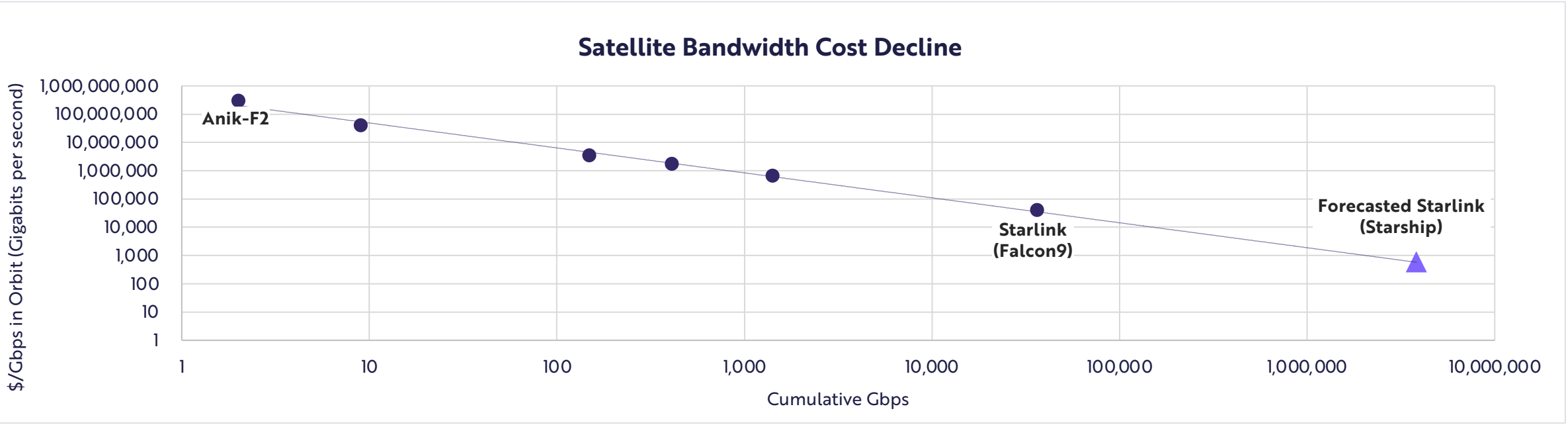
Source: ARK Investment Management LLC, 2021; Union of Concerned Scientists Satellite Database, https://www.cnbc.com/2021/11/05/space-companies-ask-fcc-to-approve-38000-broadband-satellites.html, https://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=5092&context=smallsat

Wright's Law Forecasts The Cost Decline for Satellite Bandwidth

Since 2004, the cost of satellite bandwidth has dropped 7,500-fold, from $300,000,000/Gigabits per second (Gbps) to $40,000/Gbps. Based on our research, it could fall another 40-fold during the next five years to ~$1,000/Gbps, thanks to Starship, SpaceX's next-generation rocket and its next-generation satellites.

According to ARK's research, 1 Gbps can serve 200 customers. At a capital cost of ~$1,000/Gbps, SpaceX could recoup its investment with a one-time charge of $5 per customer.[1]

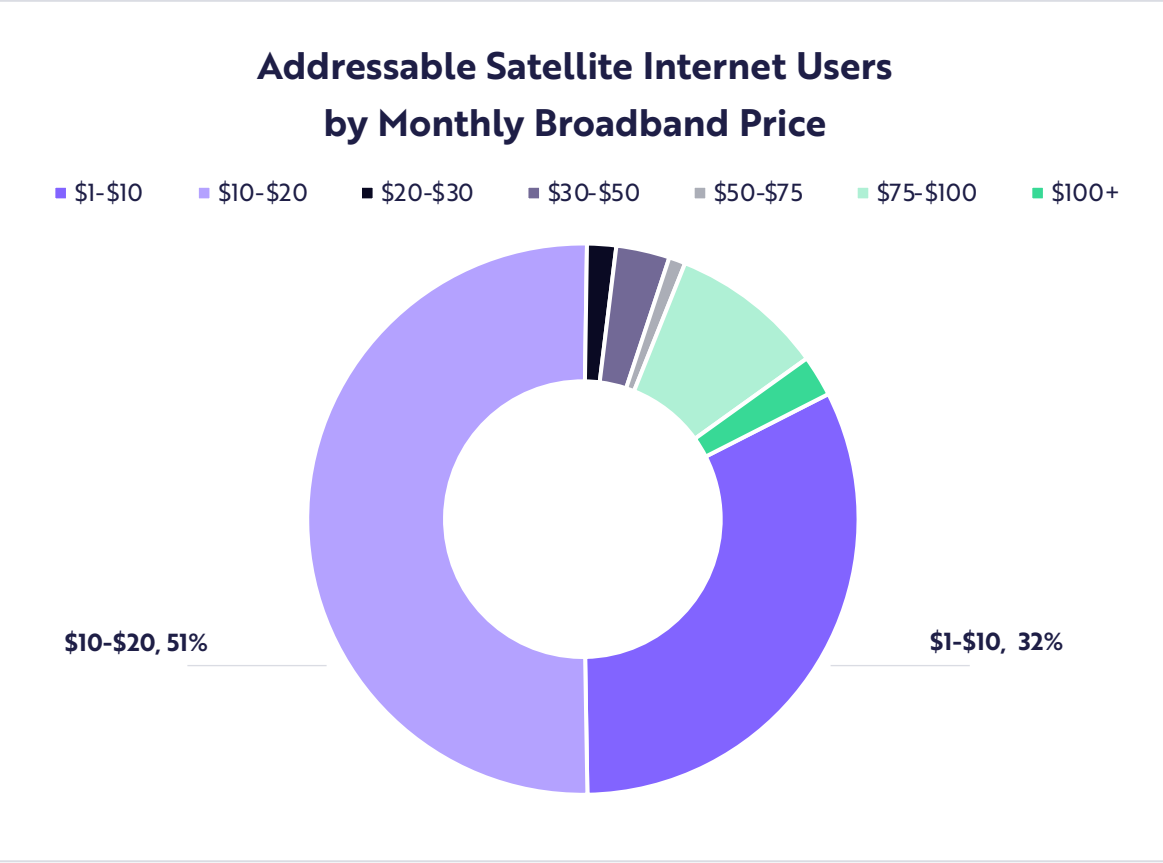


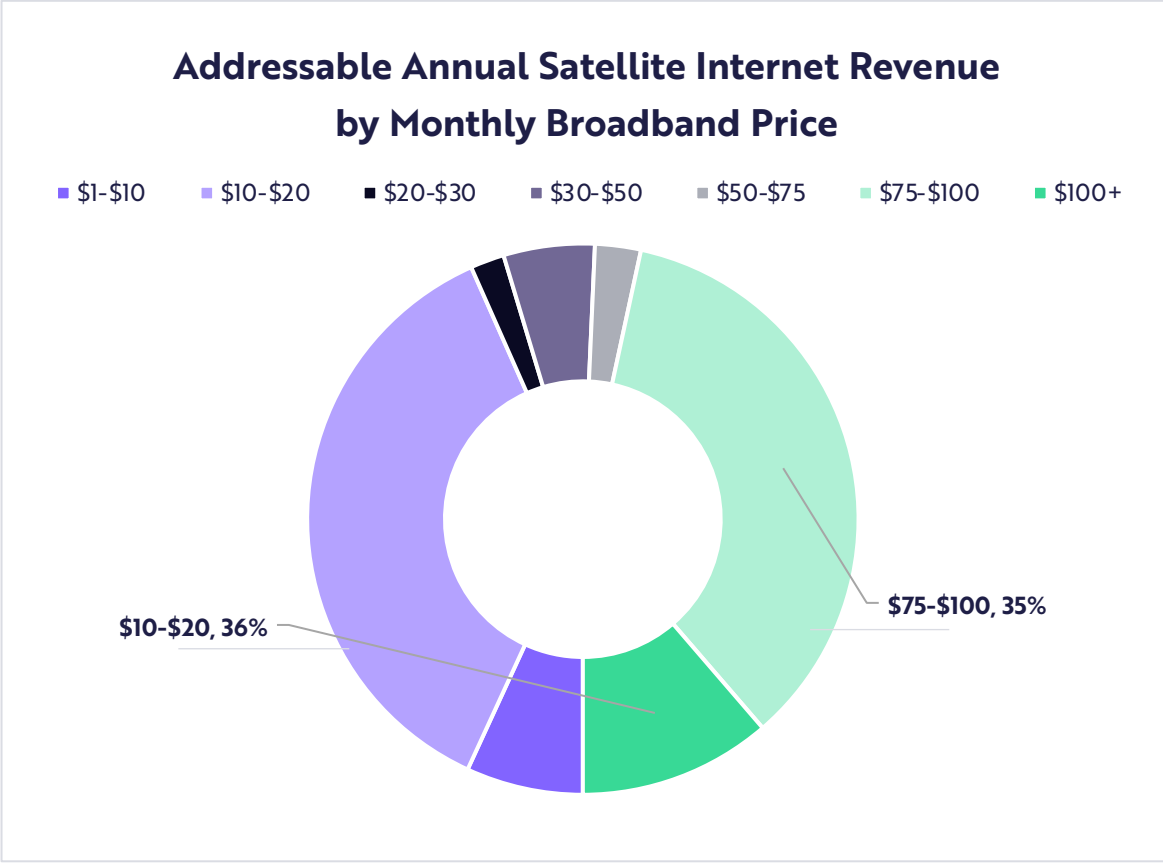
[1] This assumes an oversubscription ratio of 20, which means 20 times more people are paying for the service than are actively using it at a given time.
Please also note this calculation does not incorporate satellite lifespans, satellite utilization, and ground-based infrastructure costs, all of which will impact costs and pricing decisions.

Source: ARK Investment Management LLC, 2021, https://www.spacesymposium.org/wp-content/uploads/2017/10/R.VanderMeulen_31st_Space_Symposium_Tech_Track_paper.pdf

High Paying Customers Could Be Early Adopters Of Satellite Internet

According to ARK's research, satellite internet is likely to target two markets:
a high number of low paying customers and a low number of high paying customers.





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Source: ARK Investment Management LLC, 2021, https://www.cable.co.uk/mobiles/worldwide-data-pricing/, https://www.cable.co.uk/broadband/pricing/worldwide-comparison/

Satellite Broadband Revenues Could Approach $10 Billion Per Year In The US And $40 Billion Globally During The Next 5-10 Years

According to ARK's research, the $40 billion opportunity to serve populations without access is just one of the addressable markets for satellite broadband. The market for connected planes, trains, and motor vehicles is likely to reach $43 billion in 2026. In addition, governments are likely to add to the demand for space services.

42 Million
Americans without access to broadband

÷

2.6
People Per Household

×

$600
Average Annual Broadband Bill

=

~$10 Billion
Annual Addressable Market

3 Billion
People globally without access to broadband

÷

5
People Per Household

×

$60
Annual Broadband Bill

=

~$40 Billion
Annual Addressable Market

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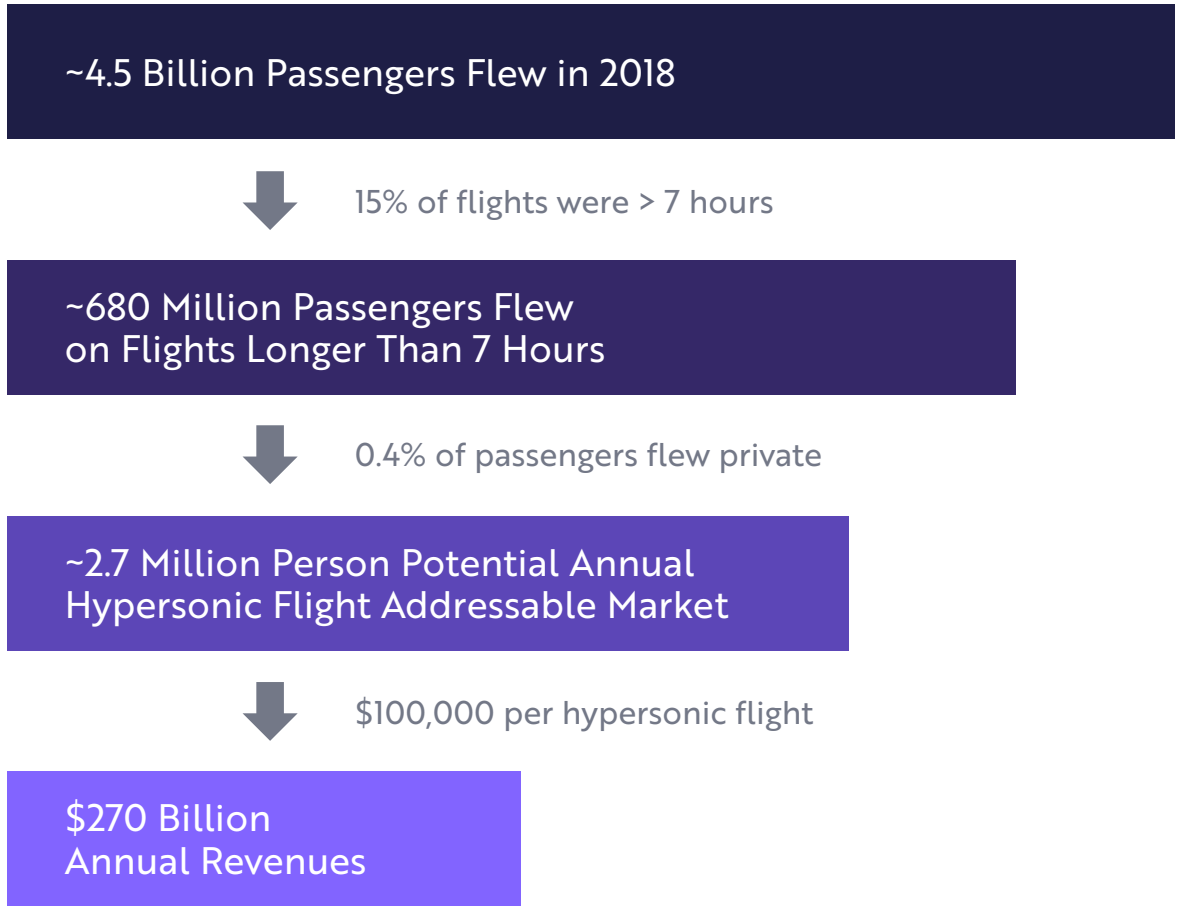
Source: ARK Investment Management LLC, 2020, based on data sourced from: Dreyfuss, Emily. "Global Internet Access Is Even Worse Than Dire Reports Suggest." Wired, Conde Nast, www.wired.com/story/global-internet-access-dire-reports/, "FCC Underestimates Americans Unserved by Broadband Internet by 50%." BroadbandNow, broadbandnow.com/research/fcc-underestimates-unserved-by-50-percent, "Worldwide Broadband Price Research 2020." Cable, www.cable.co.uk/broadband/pricing/worldwide-comparison/, "Global On-Board Connectivity Market Expected to Reach $36,842.3 Million by 2025." Allied Market Research, www.alliedmarketresearch.com/press-release/on-board-connectivity-market.html, "Space: Investing in the Final Frontier." Morgan Stanley, www.morganstanley.com/ideas/investing-in-space. "On-Board Connectivity Market." Transparency Market Research, https://www.transparencymarketresearch.com/on-board-connectivity.html.

ARK Expects The Demand For Hypersonic Flight To Skyrocket

According to our research, passengers on short-haul private flights are willing to pay roughly $15,000 for every two hours saved on private planes.

Based on the economics of the short-haul flight market, ARK estimates that passengers and businesses will be willing to pay $100,000 to save 13 hours on a 2–3 hour private hypersonic flight from New York City to Japan.

If 2.7 million passengers were to pay ~$100,000 for long-haul hypersonic flights, the market would scale to $270 billion in revenues annually. Over time, ARK believes prices could decline to compete with international business class flights today.



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Source: ARK Investment Management LLC, 2021, based on data sourced from Gollan, Doug. "Why, When And Where The Super Rich Fly Their Private Jets." Forbes, Forbes Magazine, 10 Oct. 2018, www.forbes.com/sites/douggollan/2018/10/10/why-when-and-where-the-super-rich-fly-their-private-jets/?sh=215c29c822e1, Charter Market Report 2018, The Federal Aviation Administration, the Bureau of Transportation Statistics, and Flight Aware.

For more research on disruptive innovation visit www.ark-invest.com

Please note, companies that ARK believes are capitalizing on disruptive innovation and developing technologies to displace older technologies or create new markets may not in fact do so and/or may face political or legal attacks from competitors, industry groups, or local and national governments.

ARK aims to educate investors and to size the potential opportunity of Disruptive Innovation, noting that risks and uncertainties may impact our projections and research models. Investors should use the content presented for informational purposes only, and be aware of market risk, disruptive innovation risk, regulatory risk, and risks related to Deep Learning, Digital Wallets, Battery Technology, Autonomous Technologies, Drones, DNA Sequencing, CRISPR, Robotics, 3D Printing, Bitcoin, Blockchain Technology, etc. Cryptocurrency Risk. Cryptocurrencies (also referred to as "virtual currencies" and "digital currencies") are digital assets designed to act as a medium of exchange. Cryptocurrency is an emerging asset class. There are thousands of cryptocurrencies, the most well-known of which is bitcoin. Cryptocurrency generally operates without central authority (such as a bank) and is not backed by any government. Cryptocurrency is not legal tender. Federal, state and/or foreign governments may restrict the use and exchange of cryptocurrency, and regulation in the U.S. is still developing. The market price of bitcoin and other cryptocurrencies have been subject to extreme fluctuations. Similar to fiat currencies (i.e., a currency that is backed by a central bank or a national, supra-national or quasi-national organization), cryptocurrencies are susceptible to theft, loss and destruction. Cryptocurrency exchanges and other trading venues on which cryptocurrencies trade are relatively new and, in most cases, largely unregulated and may therefore be more exposed to fraud and failure than established, regulated exchanges for securities, derivatives and other currencies. Cryptocurrency exchanges may stop operating or permanently shut down due to fraud, technical glitches, hackers or malware, which may also affect the price of cryptocurrencies. Cryptocurrency Tax Risk. Many significant aspects of the U.S. federal income tax treatment of investments in bitcoin and other cryptocurrencies are uncertain and still evolving.

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