



Big Ideas 2021

January 26, 2021 | For Informational Purposes Only

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PAST PERFORMANCE IS NOT INDICATIVE OF FUTURE PERFORMANCE, FUTURE RETURNS ARE NOT GUARANTEED.



Introduction

ARK'S BIG IDEAS

ARK aims to identify large-scale investment opportunities by focusing on who we believe to be the leaders, enablers, and beneficiaries of disruptive innovation. While we believe innovation is the key to growth, the opportunities it creates can be missed or misunderstood by traditional investment managers who are more focused on sectors, indexes, short-term earnings, and price movements.

ARK seeks to gain a deeper understanding of the convergence, market potential, and long-term impact of disruptive innovation by researching a global universe that spans sectors, industries, and markets. Today, we are witnessing an acceleration in new technological breakthroughs.

To enlighten investors on the impact of these breakthroughs and the opportunities they should create, we began publishing Big Ideas in 2017. This annual research report seeks to highlight the latest developments in innovation and offers some of our most provocative research conclusions for the year.

We hope you enjoy our “Big Ideas” for 2021.

About ARK

Headquartered in New York City, ARK Investment Management LLC is a federally registered investment adviser and privately held investment firm. ARK specializes in thematic investing in disruptive innovation and strives to invest at the pace of innovation.

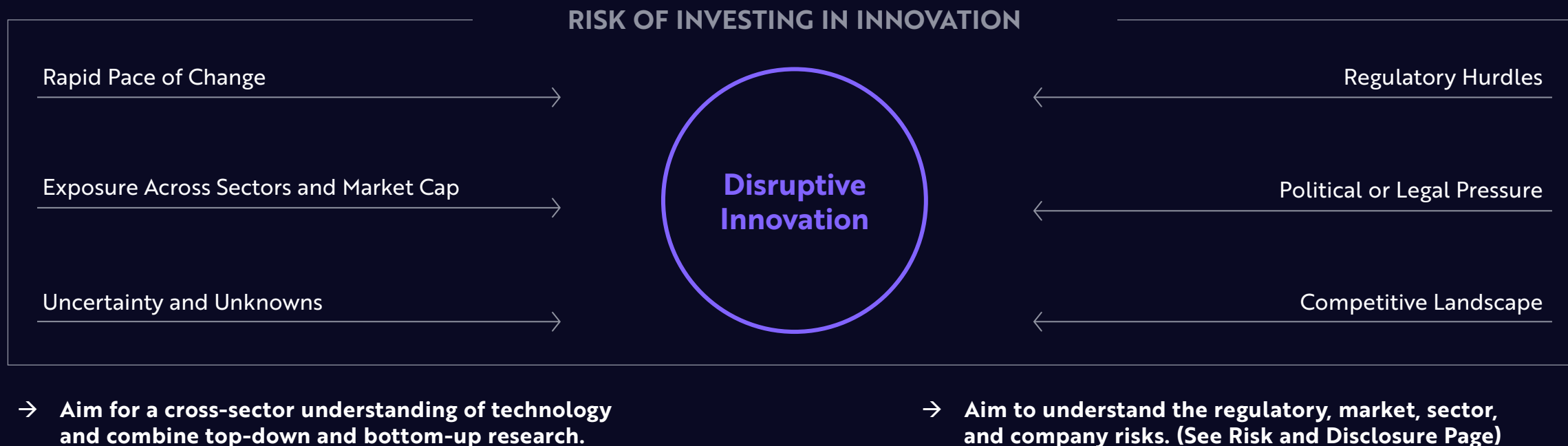
To learn more visit ark-invest.com



DISCLOSURE

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.





Big Ideas 2021

ARK requires a big idea to be investable and long-term. This report includes research that has been updated or revised over the years as well as completely new sections marked with "✦".

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Deep Learning

Deep Learning Could Be The Most Important Software Breakthrough Of Our Time

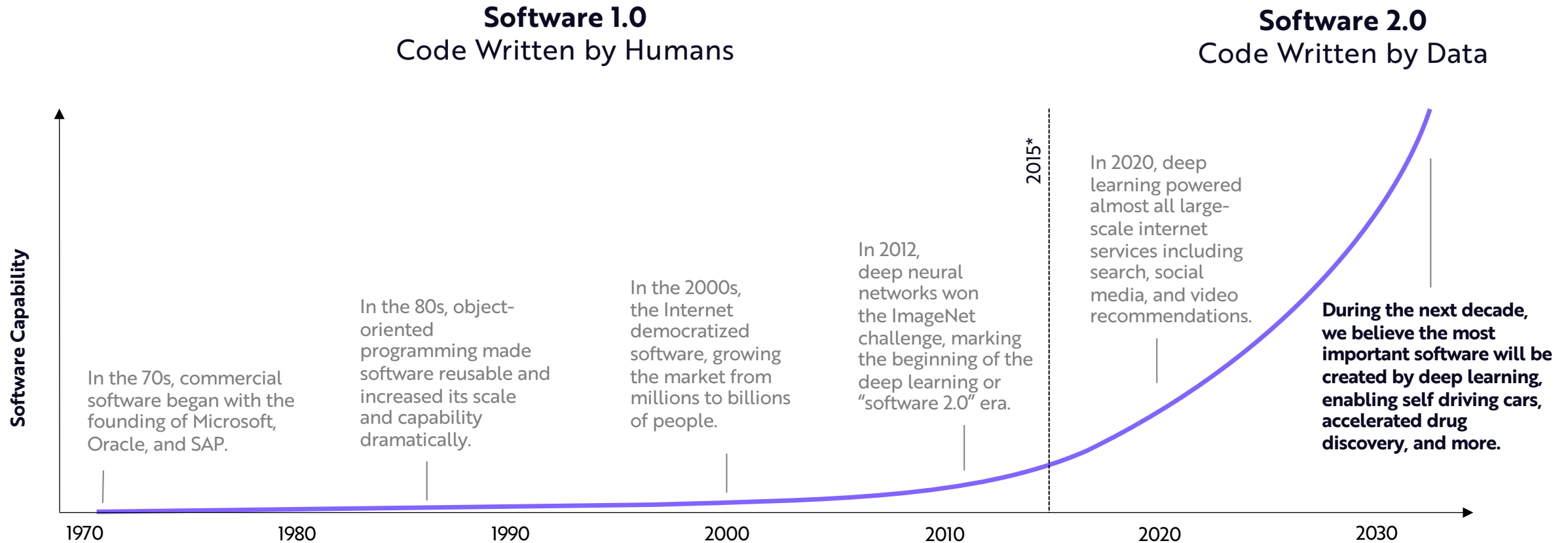
- Until recently, humans programmed all software. Deep learning, a form of artificial intelligence (AI), uses data to write software. By “automating” the creation of software, deep learning could turbocharge every industry.
- **According to ARK's research, deep learning will add \$30 trillion to the global equity market capitalization during the next 15-20 years.**



01



Deep Learning Is Software 2.0



*In 2015, deep learning started gaining large scale industry adoption. Chart is for illustrative purposes and is not to scale.

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Source: ARK Investment Management LLC, 2020 based on data sourced from: Neeraj Agrawal, and Logan Bartlett. "Battery Ventures' Software 2019." IPOs, M&A, and Forces of Growth — Here's Software 2019, May 2019, www.battery.com/powered/software-2019/.



Deep Learning Is Creating The Next Generation Of Computing Platforms

Conversational Computers

Powered by AI, smart speakers answered 100 billion voice commands in 2020, 75% more than in 2019.



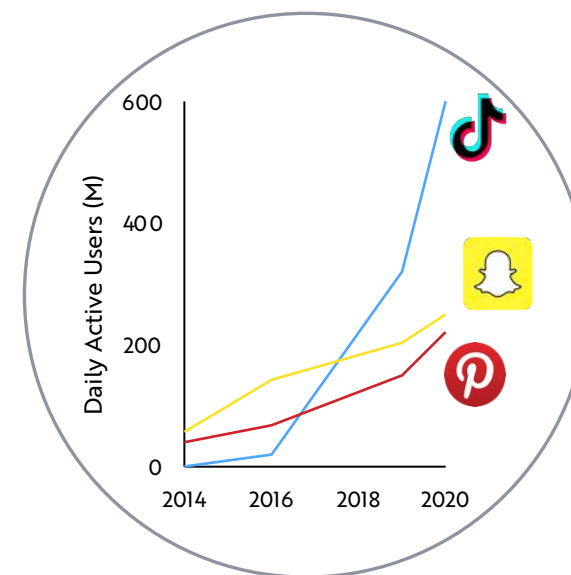
Self-Driving Cars

Waymo's autonomous vehicles have collected more than 20 million real world driving miles across 25 cities, including San Francisco, Detroit, and Phoenix.



Consumer Apps

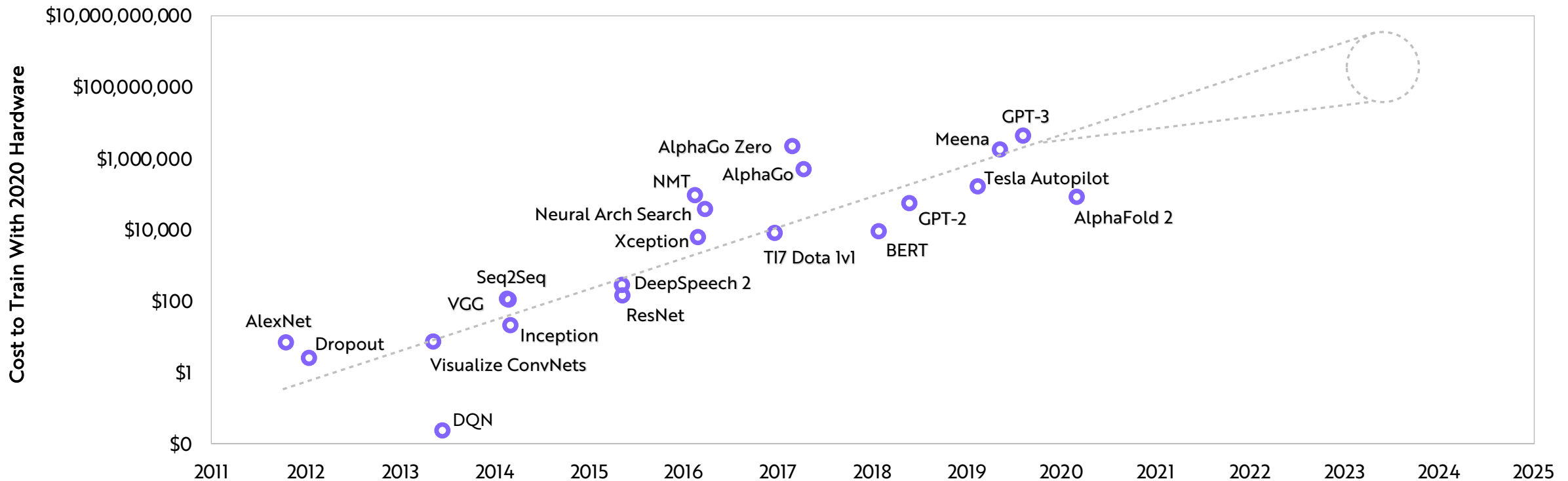
TikTok, which uses deep learning for video recommendations, has outgrown Snapchat and Pinterest combined.





Deep Learning Requires Boundless Computational Power

While advances in hardware and software have been driving down AI training costs by 37% per year, the size of AI models is growing much faster, 10x per year. As a result, total AI training costs continue to climb. We believe that state-of-the-art AI training model costs¹ are likely to increase 100-fold, from roughly \$1 million today to more than \$100 million by 2025.

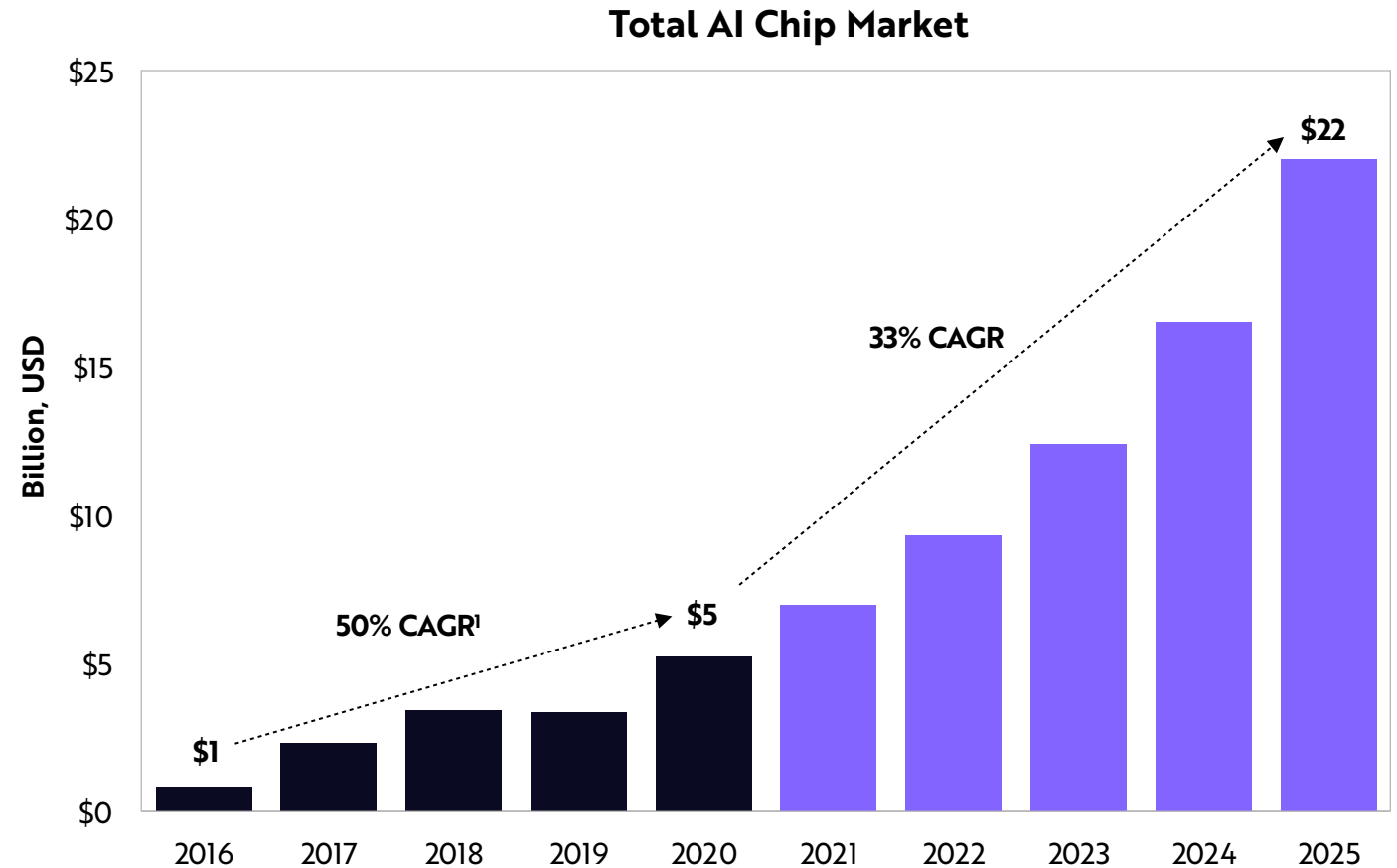


[1] AI training cost based on AWS A100 and GCP TPU v4 instance list price as of Dec 2020. Actual costs may be up to 10x lower due to software tuning and on-premise hardware. Data series based on work by Hernandez, Danny, and Tom Brown. "AI and Efficiency." OpenAI, OpenAI, May 2020, openai.com/blog/ai-and-efficiency/. Note for Chart: The dotted circle shows a range of cost possibilities with the bottom line representing the outcome if progress slows down. 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, 2020.



Deep Learning Is Creating A Boom In AI Chips

- As AI training cost grows from \$1 to \$100 million per project, specialized processors such as GPUs or TPUs will account for a majority of the incremental growth.
- ARK estimates that data center spending on AI processors will scale more than four-fold during the next five years, from \$5 billion a year today to \$22 billion in 2025.
- The upcoming “deployment phase” for deep learning will democratize access to AI, benefitting not only large internet companies but also every industry in the economy.



[1] CAGR: Compound Annual Growth Rate.

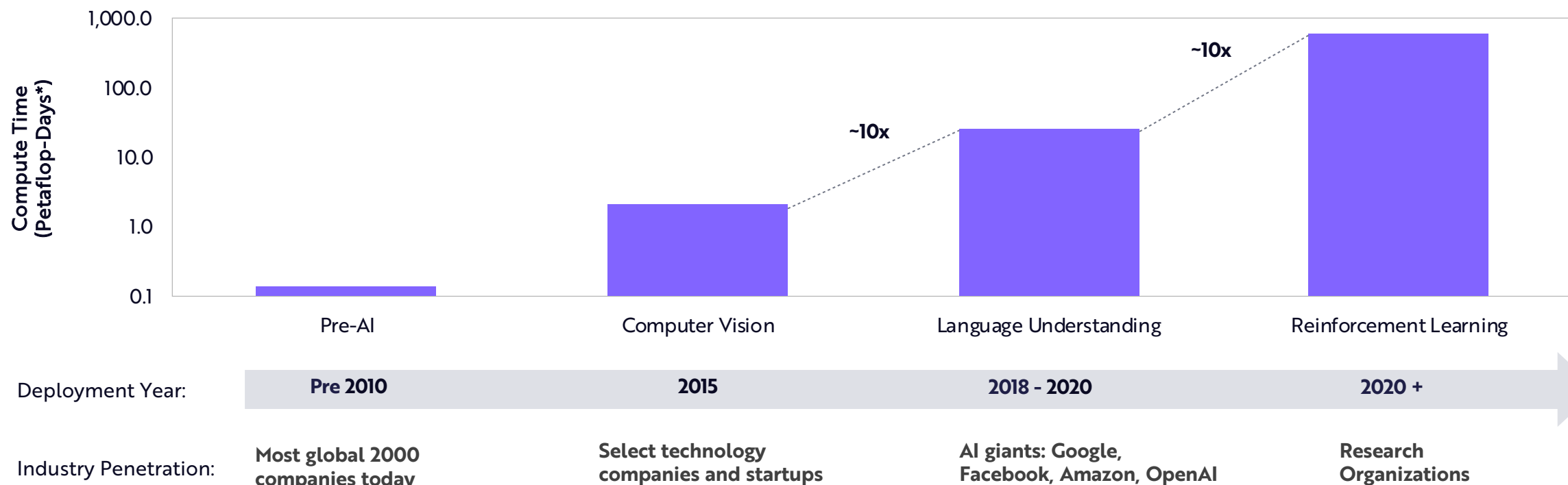
Forecasts are inherently limited and cannot be relied upon. | Source: ARK Investment Management LLC, 2020 based on data sourced from company derived statistics.



AI Is Expanding From Vision To Language

2020 was the breakthrough year for conversational AI. For the first time, AI systems could understand and generate language with human-like accuracy. Conversational AI requires 10x the computing resources of computer vision and should spur large investments in the coming years.

Training Time For Different AI Systems



*A "Petaflop-Day" is performing a quadrillion operations per second for a day.

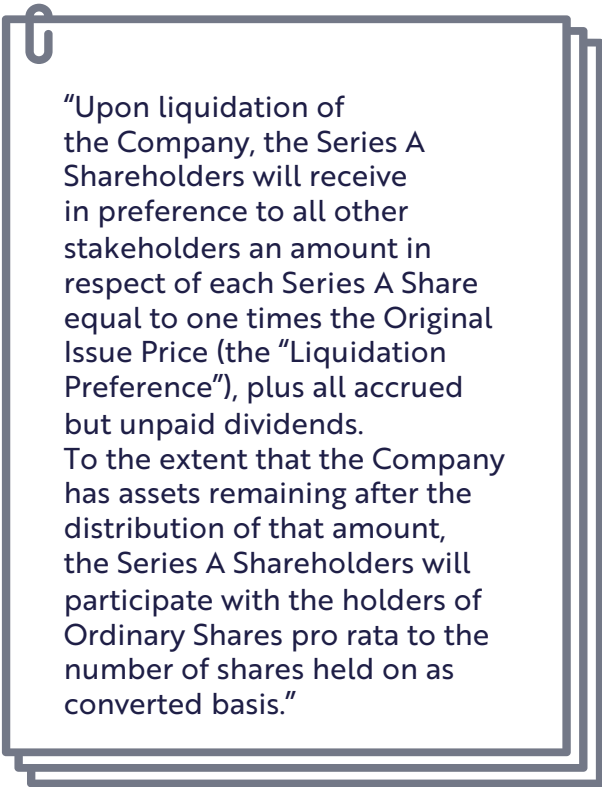
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Source: ARK Investment Management LLC, 2020 based on data sourced from Hernandez, Danny, and Tom Brown. "AI and Efficiency." OpenAI, OpenAI, May 2020, openai.com/blog/ai-and-efficiency/.



OpenAI's GPT-3 Is The First AI That "Understands" Language

GPT-3 translates "legalese" into plain English:



"Upon liquidation of the Company, the Series A Shareholders will receive in preference to all other stakeholders an amount in respect of each Series A Share equal to one times the Original Issue Price (the "Liquidation Preference"), plus all accrued but unpaid dividends. To the extent that the Company has assets remaining after the distribution of that amount, the Series A Shareholders will participate with the holders of Ordinary Shares pro rata to the number of shares held on as converted basis."



"If the startup is wound up, the Series A investors will be paid back at least what they invested and they will also share any leftover assets with ordinary shareholders."

GPT-3 also can:

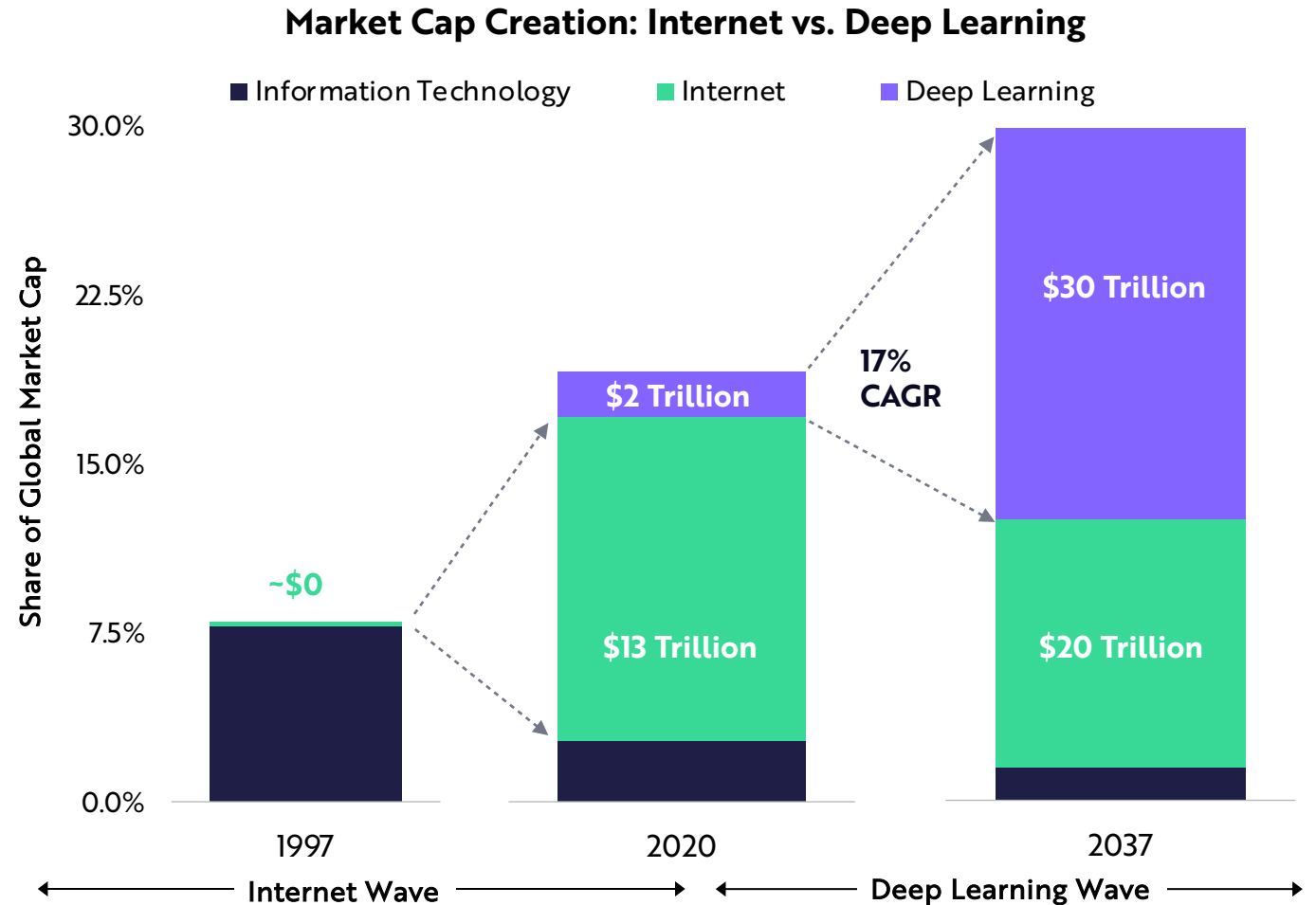
- Write emails
- Design webpages
- Write code in a dozen computer languages
- Retrieve historical facts
- Translate languages
- Diagnose diseases
- Converse as a therapist
- And more...



SIZING THE OPPORTUNITY

Deep Learning Could Create More Economic Value Than The Internet Did.

- Over two decades the Internet added \$13 trillion to equity market capitalizations globally. Deep learning has created \$2 trillion in market capitalization as of 2020.
- **ARK believes that deep learning will add \$30 trillion to equity market capitalizations during the next 15-20 years.**



Forecasts are inherently limited and cannot be relied upon.

Source: ARK Investment Management LLC, 2020 based on data sourced from World Federation of Exchanges, "H1 2020 Market Highlights", Aug 2020, <https://www.world-exchanges.org/news/articles/h1-2020-market-highlights>.



The Re-Invention of the Data Center

Data Centers—The Power Plants Of Computation— Are Going Through A Revolution

- Cheaper, faster, and more power efficient processors are starting to displace Intel—which traditionally had captured over 90% of all processor revenue.
- For cloud computing, we believe ARM, RISC-V, and graphics processing units (GPUs) are likely to emerge as the new powerhouse processors. Together they could scale at a 45% annual rate to \$19 billion in revenue by 2030.
- **In the data center, we believe accelerators, dominated by GPUs, will become the dominant processors for new workloads, growing 21% at an annual rate to \$41 billion by 2030.**

02

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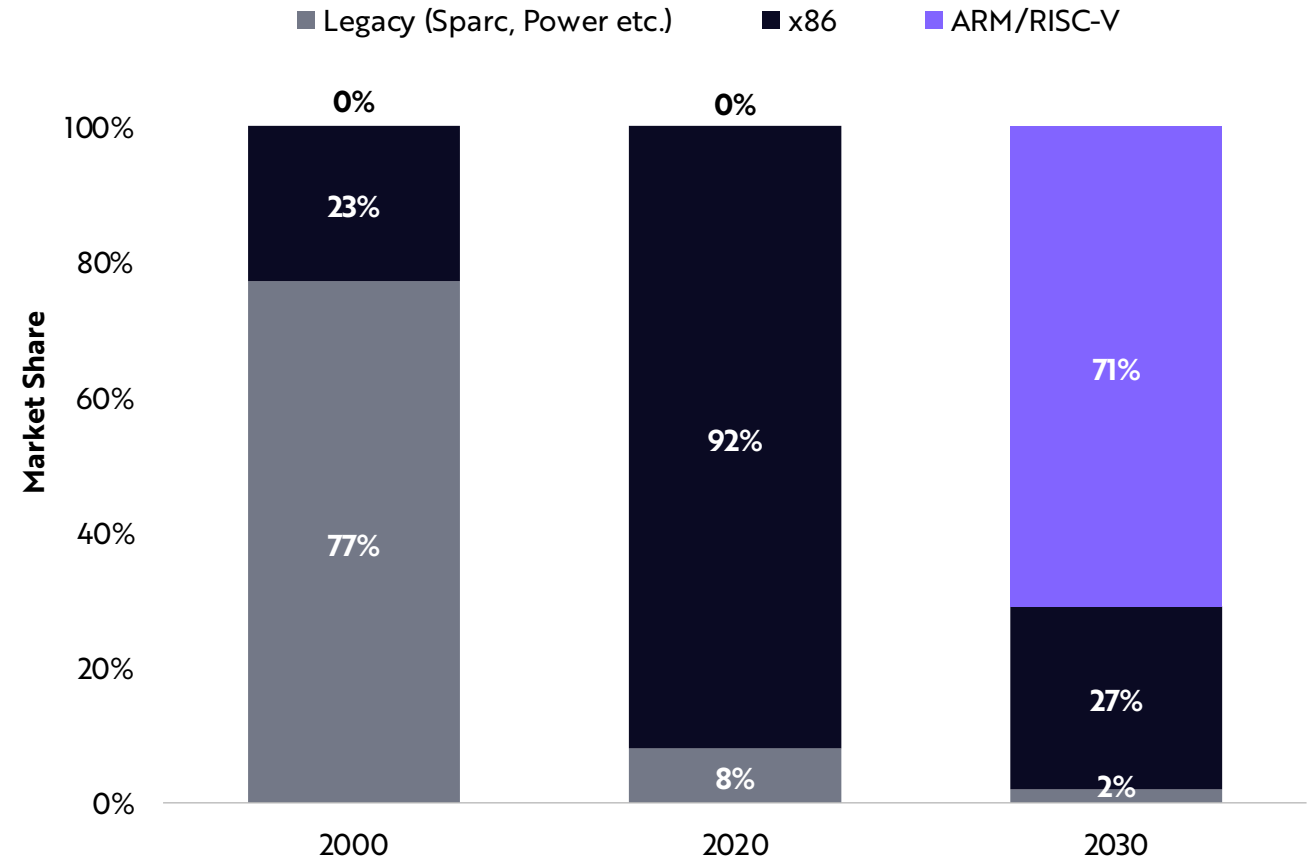
Source: ARK Investment Management LLC, 2020 based on data sourced from IDC "IDC Worldwide Quarterly Server Tracker", Dec 2020, <https://www.idc.com/getdoc.jsp?containerId=prUS47123620>.



New Architectures Re-Invent The Data Center Every Few Decades

- The last great migration of the data center was from RISC processors in the 90s to Intel's low cost, PC derived x86 architecture. Leveraging the scale of the PC market, Intel disrupted high end incumbents.
- Today, ARM processors are leveraging the scale of the mobile ecosystem to disrupt Intel. Applying open-source principles to hardware, RISC-V also is emerging as a standard in low-cost computing.
- We believe that the combination of ARM and RISC-V will move from 0% market share in 2020 to 71% of the server market by 2030.

The Data Center Architecture



Forecasts are inherently limited and cannot be relied upon.

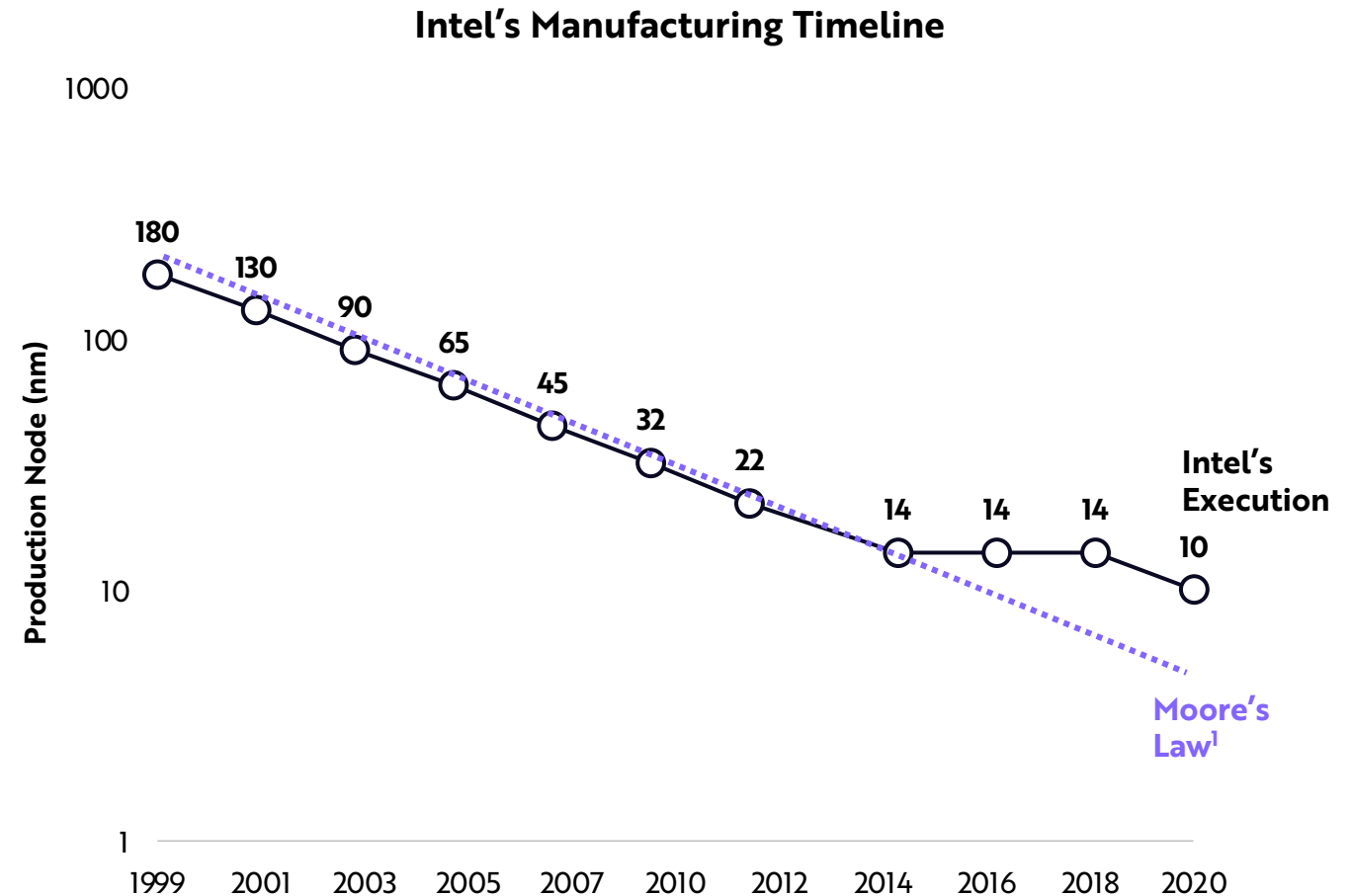
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Source: ARK Investment Management LLC, 2020 based on data sourced from: International Data Corporation (IDC) Worldwide Quarterly Server Tracker 2000–2020.



Intel Seems Frozen In Time

- Once the world leader of semiconductor manufacturing, Intel seems to have lost its way.
- Intel delayed its 10nm processor by four years, allowing its competitors—TSMC and AMD—to lead the market in 2020.
- As of 2020, Intel still has not shipped a 10nm server chip. A full generation ahead of Intel, TSMC is mass producing 5nm processors.



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

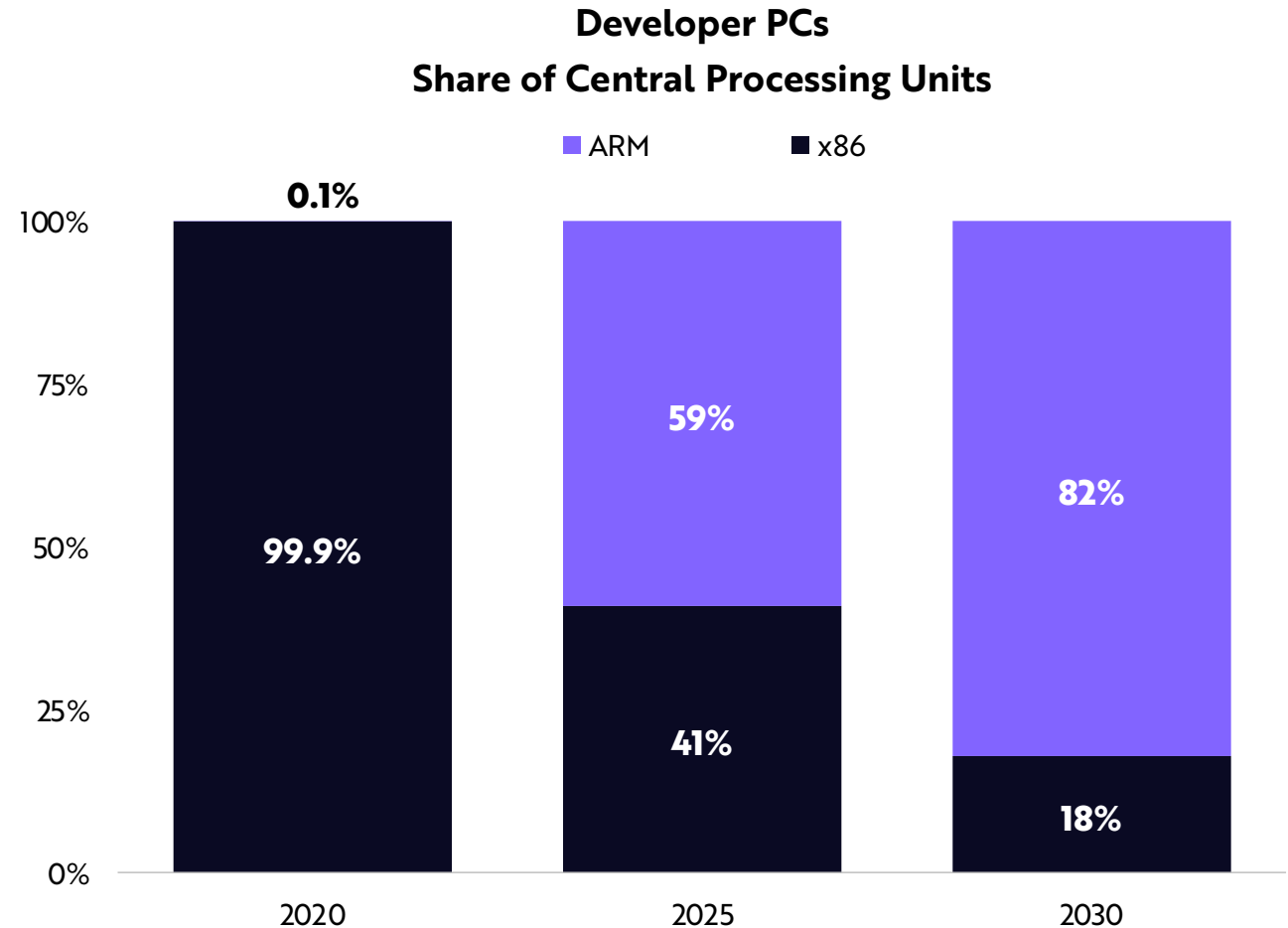
[1] Moore's Law— named after Gordon Moore for his work in 1965 – focuses on cost as a function of time. Specifically, it states that the number of transistors on a chip would double every two years.

Source: ARK Investment Management LLC, 2020 based on data sourced from: AnandTech.



ARM Could Power The Majority Of Developer PCs By 2030

- Almost all software developers write code on Intel's x86 PCs running Windows, Mac, or Linux operating systems.
- Apple plans to transition Macs, which are used by one in three developers, from x86 to ARM based central processing units (CPUs) over the next two years.
- At the same time, Microsoft is doubling down on its efforts to support Windows on ARM processors.
- According to ARK's research, by 2030 most developer PCs could be powered by ARM CPUs, marking the end of the Intel x86 era.



Forecasts are inherently limited and cannot be relied upon.

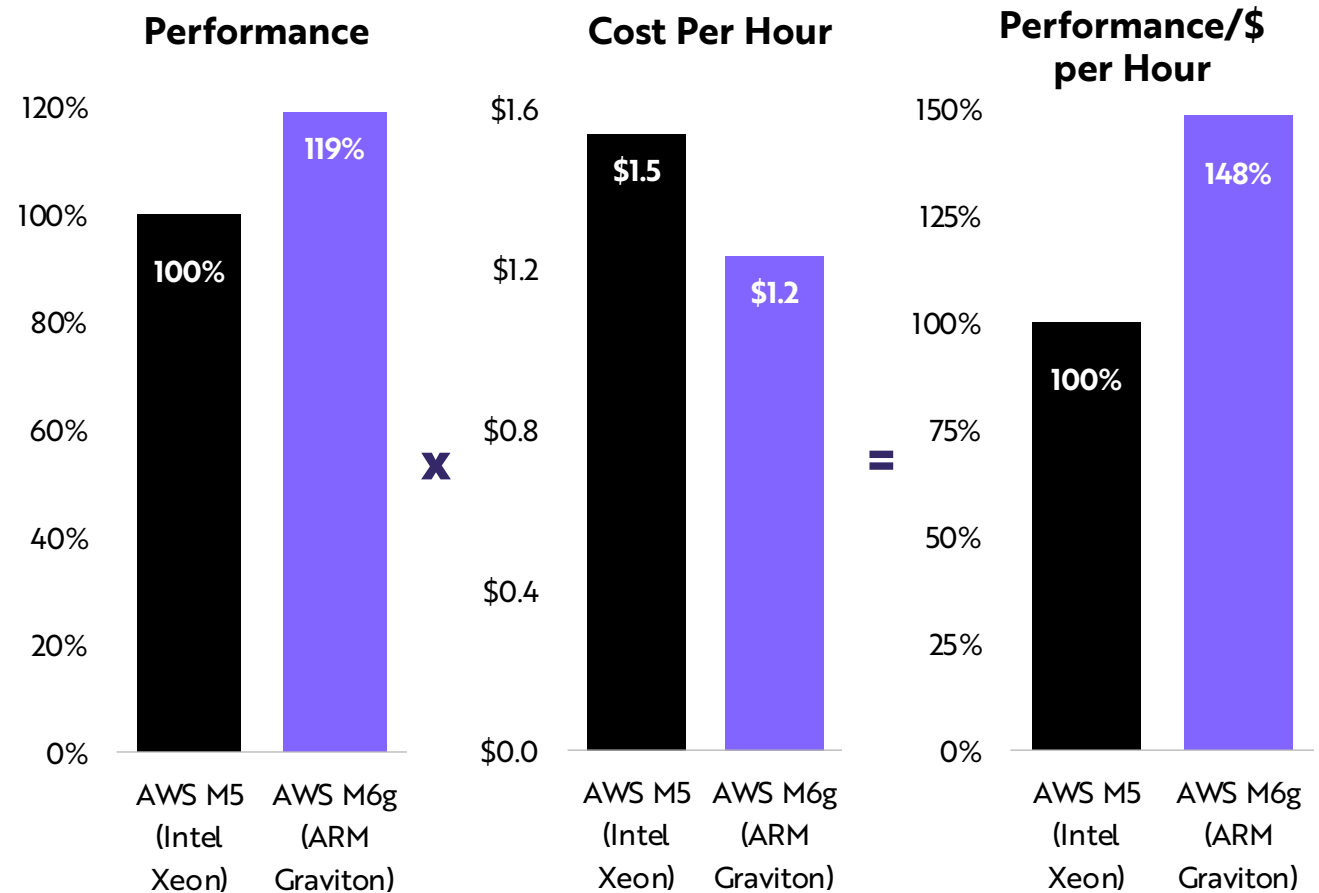
For informational purposes only and should not be considered investment advice, or a recommendation to buy, sell or hold any particular security.

Source: ARK Investment Management LLC, 2020 based on data sourced from: Stackoverflow. "Stack Overflow Developer Survey 2020." insights.stackoverflow.com/survey/2020.



ARM Could Become The New Standard In The Cloud

- The public cloud, the default platform for deploying new applications, generated \$140 billion in global revenues in 2020.
- Amazon Web Services (AWS)—the largest public cloud provider in the world—launched the Graviton 2 ARM CPU in 2020, reducing its need to purchase chips from Intel and AMD.
- AWS Graviton 2 is cheaper and faster than Intel CPUs, offering 48% higher performance per dollar.
- In the future, AWS is likely to migrate most of its servers to ARM based processors.

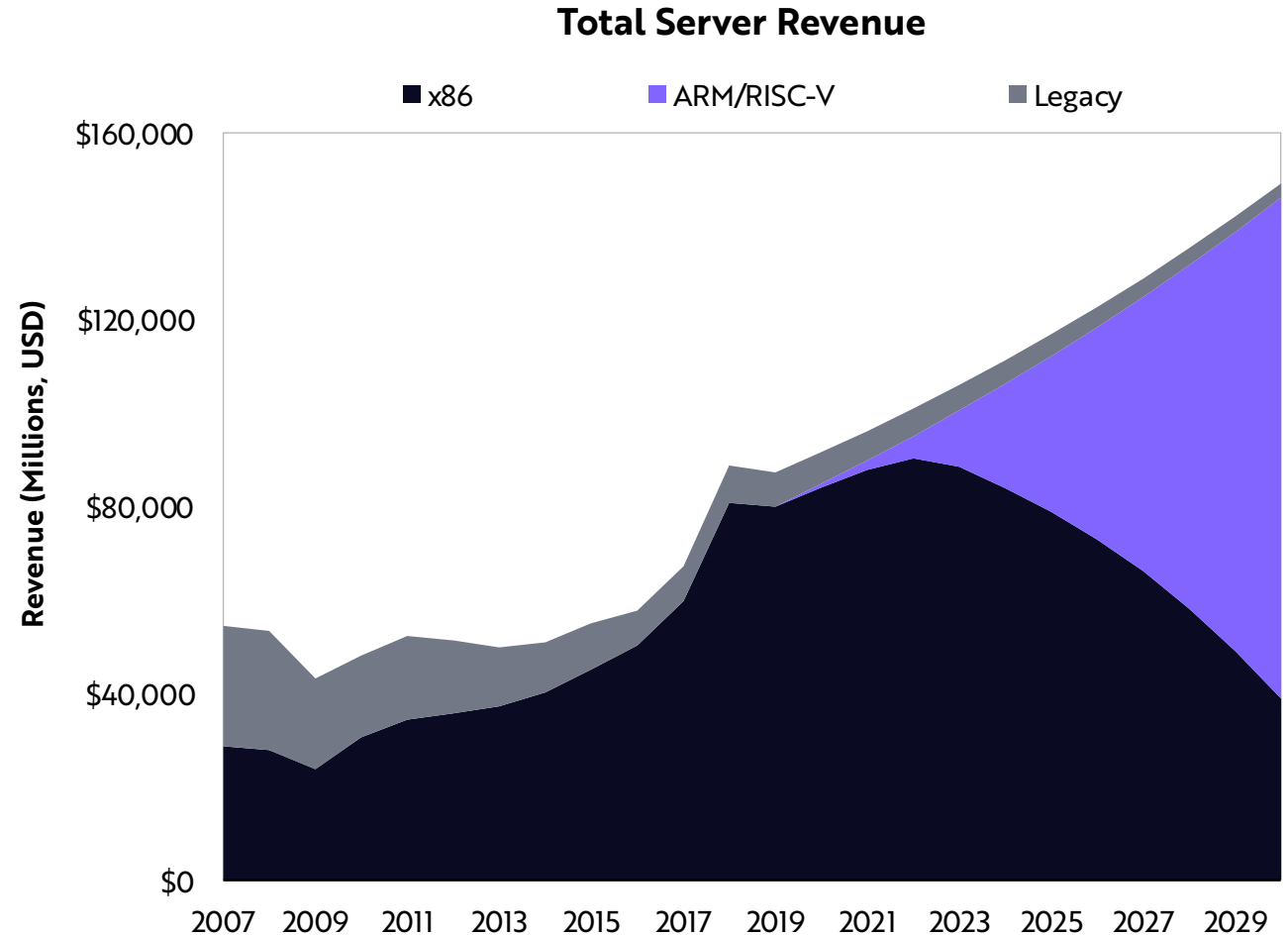


Forecasts are inherently limited and cannot be relied upon. | For informational purposes only and should not be considered investment advice, or a recommendation to buy, sell or hold any particular security. Note for Third Chart: Time is implied. The math is: $(119/1.2)/(100/1.5)-1$. Source: ARK Investment Management LLC, 2020 based on data sourced from: "Global Cloud Services Market Q2 2020." Canalys, www.canalys.com/newsroom/worldwide-cloud-infrastructure-services-Q2-2020, Michael Larabel. "Benchmarking Amazon's Graviton2 Performance With 64 Neoverse N1 Cores Against Intel Xeon, AMD EPYC." Phoronix, May 2020, www.phoronix.com/scan.php?page=article&item=amazon-graviton2-benchmarks&num=12, Daly, Donald J., and Donald J. Daly. "Economics 2: EC2." Amazon, CGA Canada Publications, 1987, aws.amazon.com/ec2/pricing/.



ARM & RISC-V Could Become The New Processor Standards By 2030

- We believe that PCs and servers adopting ARM processors will create the first ecosystem with enough scale, tooling, and vendor support to challenge Intel's x86.
- ARM server revenue could scale 100-fold, from less than \$1 billion in 2020 to \$100 billion in 2030, a level higher than x86 today. RISC-V could make a meaningful contribution during the same time.
- Like mainframes, installed x86 compute capacity could continue to grow but its revenue base could be cut in half.



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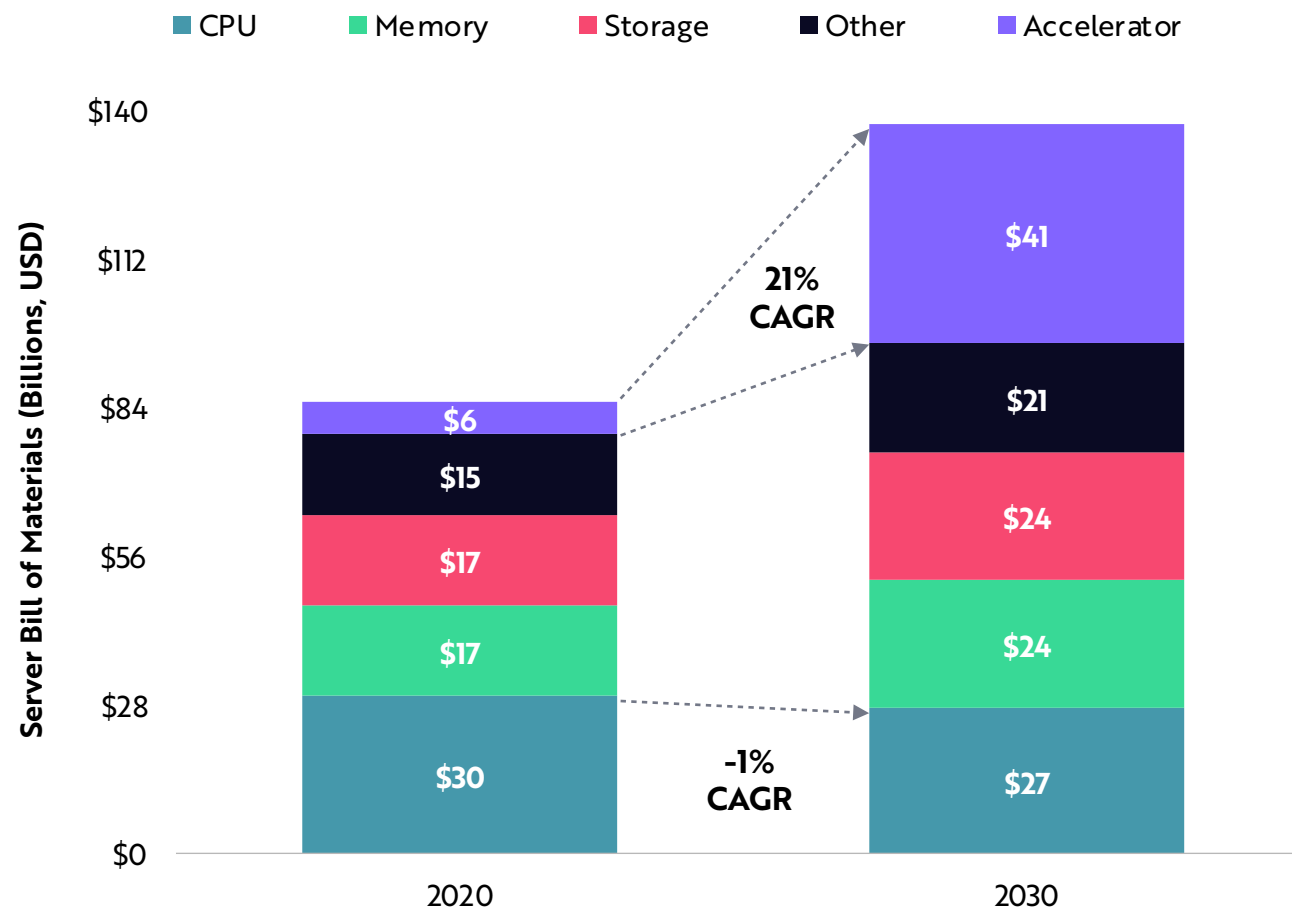
Source: ARK Investment Management LLC, 2020 based on data sourced from: International Data Corporation (IDC) Worldwide Quarterly Server Tracker 2007–2020



By 2030, The Accelerator Should Replace The CPU As The Main Server Compute Engine

- Accelerators, such as GPUs, Tensor Processing Units (TPUs), and field programmable gate arrays (FPGAs), perform the most demanding computing tasks including artificial intelligence (AI), analytics, drug discovery, and cloud gaming.
- Despite intense competition, ARK believes that GPUs will continue to dominate the accelerator market during the next five years thanks to their unmatched programmability and software stack.

Potential Server Spending Over The Next Ten Years





SIZING THE OPPORTUNITY

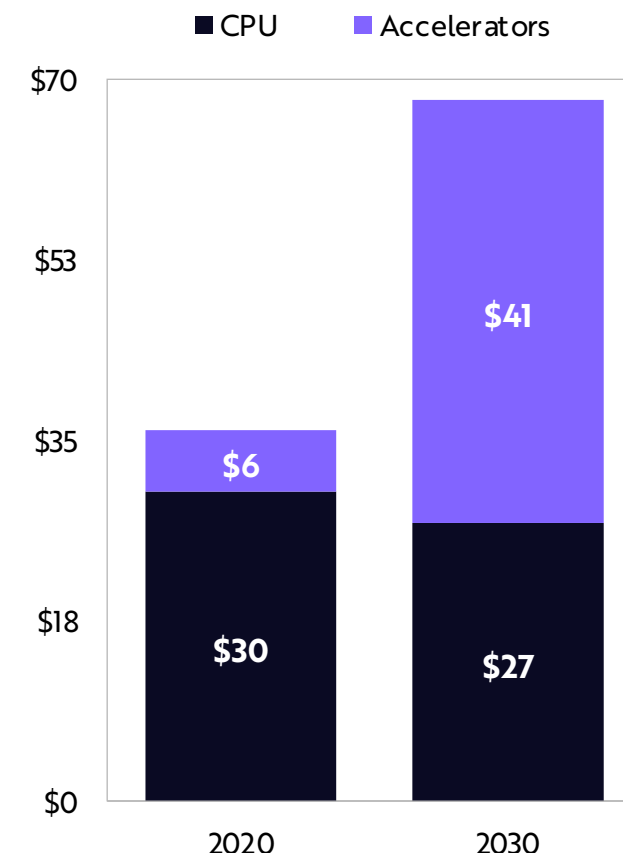
ARK Believes That Server Processors Will Transform In The Next Decade.

- ARM and RISC-V are likely to displace Intel's x86 in the cloud. Together they could grow 45% per year to reach \$19 billion in CPU revenue and \$100 billion in server revenue by 2030.
- We believe accelerators, dominated by GPUs, will become the dominant processor in the data center, growing 21% at an annual rate to \$41 billion.**

Data Center CPU Revenue



Data Center Accelerator Revenue



Forecasts are inherently limited and cannot be relied upon.

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Source: ARK Investment Management LLC, 2020 based on data sourced from company quarterly filings by Nvidia, Intel, AMD, and others.



Virtual Worlds

Virtual Worlds Consist Of Video Games, Augmented Reality, And Virtual Reality

- A virtual world is defined as a computer-simulated environment that can be accessed by anyone at any time. Society interacts daily with virtual worlds which today are in their infancy.
- **According to our research, revenue from virtual worlds will compound 17% annually from roughly \$180 billion today to \$390 billion by 2025.**
- Today, virtual worlds are independent from each other, but in the future they could become interoperable, culminating in what futurists have deemed 'The Metaverse.'



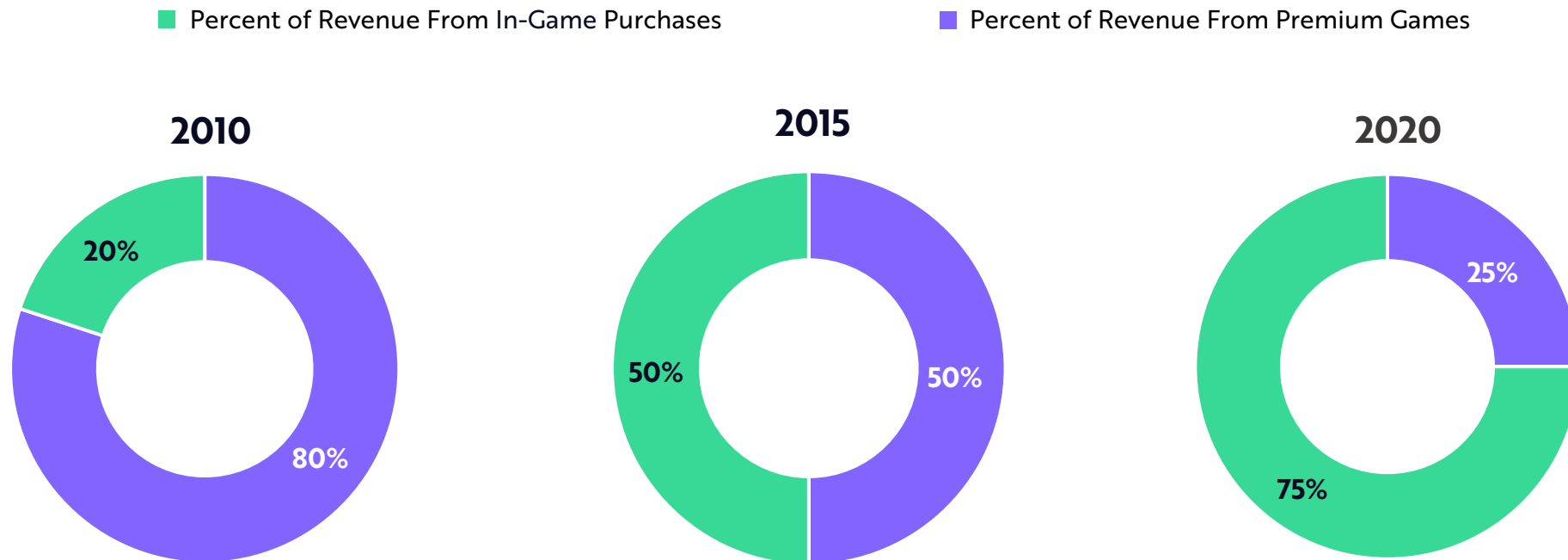
03



Video Game Monetization Models Are Shifting To Virtual Goods

As video games have evolved, so have their business models. According to our research, during the past 10 years in-game purchases¹ as a percent of total gaming revenue increased from 20% to 75%. They could hit 95% by 2025.

Breakdown of Global Gaming Revenue



[1] ARK defines in-game purchases as revenues generated through the sales of in-game items, including expansion or content packs, cosmetics/skins, power-ups, time savers, loot boxes, playable characters, content passes for a one-off fee (battle/season pass), in-game currencies, content passes for a recurring fee, and reward passes. | Forecasts are inherently limited and cannot be relied upon.
Source: ARK Investment Management LLC based on data sourced from "Newzoo Global Mobile Market Report 2020: Free Version." Newzoo, 30 Sept. 2020, newzoo.com/insights/trend-reports/newzoo-global-mobile-market-report-2020-free-version/; "2019 Year In Review." SuperData, a Nielsen Company, www.superdataresearch.com/2019-year-in-review/; Savov, Vlad. "Digital Games Distribution Earned \$3.8 Billion in 2010, a Quarter of Entire Video Game Market." Engadget, 14 Feb. 2020, www.engadget.com/2011-06-09-digital-games-distribution-earned-3-8-billion-in-2010-a-quarter.html.



ARK Believes The Monetization Of Gaming Will Increase

Thanks to the proliferation of in-game purchases, economic power is shifting from developers to gamers. In fact, with lower barriers to entry, many gamers have become developers. In our view, this shift has increased the monetization rates of video games. During the next five years, the cost per hour of playing video games is likely to increase by 20% but will remain a bargain relative to other sources of entertainment and information.

Direct vs. Indirect¹ Monetization in the US



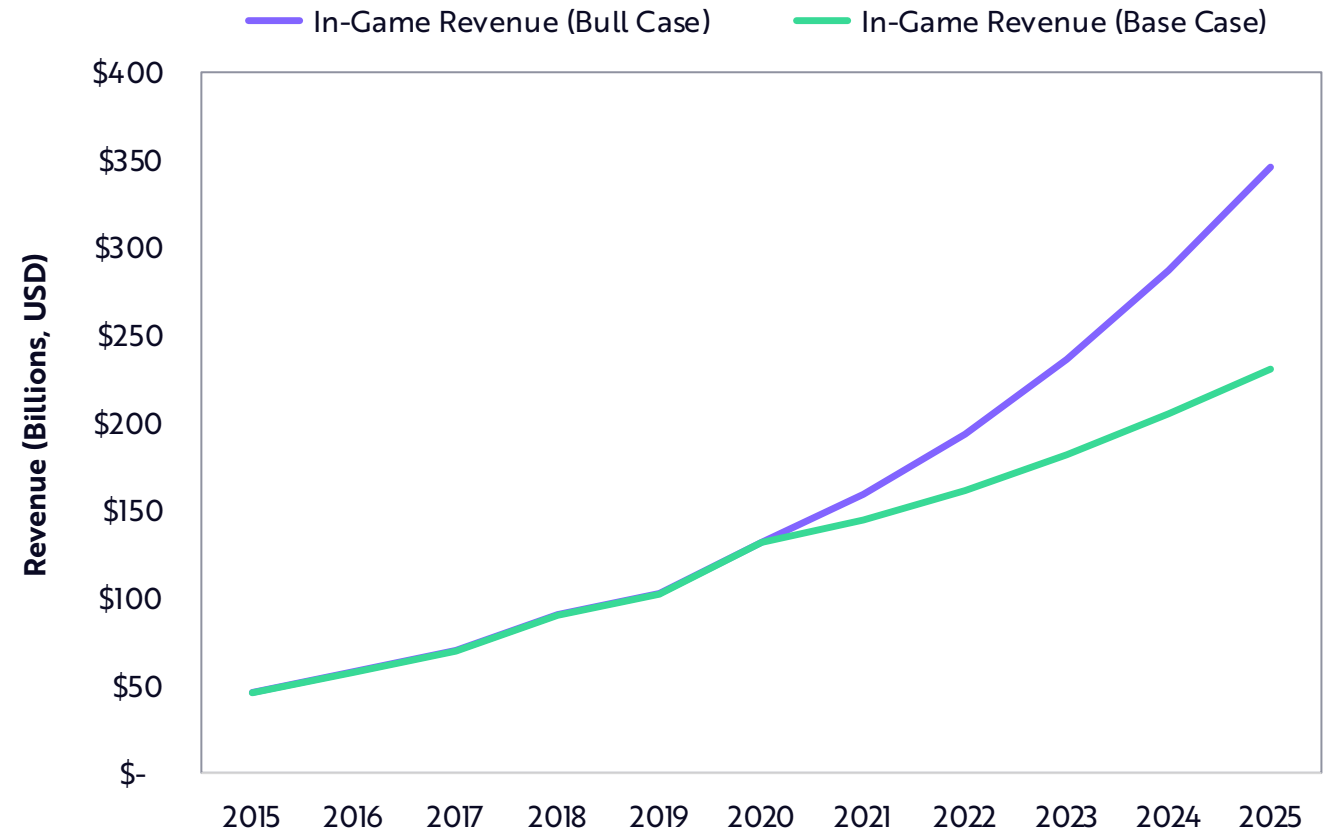
Forecasts are inherently limited and cannot be relied upon. Chart data is as of 2020. | [1] Direct Monetization is when the consumer pays, an example being a subscription. Indirect Monetization is when a 3rd party funds the product, an example being advertising. [2] SVOD: Subscription Video On Demand. [3] AVOD: Ad-Based Video On Demand. | Source: ARK Investment Management LLC based on data sourced from: "Xbox Game Pass Subscriptions Hit 10 Million." The Guardian, Guardian News and Media, 30 Apr. 2020, www.theguardian.com/games/2020/apr/30/xbox-game-pass-subscriptions-hit-10-million; Warren, Tom. "Xbox Game Pass Subscribers Jump 50 Percent to 15 Million in Less than Six Months." The Verge, The Verge, 21 Sept. 2020, www.theverge.com/2020/9/21/21449219/xbox-game-pass-15-million-subscribers-microsoft-growth; Gough, Christina. "Xbox Live MAU 2020." Statista, 22 Sept. 2020, www.statista.com/statistics/531063/xbox-live-mau-number/; <https://www.npd.com/Wps/Portal/Npd/Us/News/Press-Releases/2020/More-People-Are-Gaming-in-the-Us/>; Pew Research Center, Pew Research Center, 9 Jan. 2020, www.pewresearch.org/; <https://Auditedmedia.com/>; Clark, Travis. "Netflix Says Its Subscribers Watch an Average of 2 Hours a Day - Here's How That Compares with TV Viewing." Business Insider, Business Insider, 13 Mar. 2019, www.businessinsider.com/netflix-viewing-compared-to-average-tv-viewing-nielsen-chart-2019-3; and Quarterly Earnings from: Facebook, Snap, Twitter, Pinterest, Spotify, and Alphabet.



Video Games Are Becoming "Third Places" Away From Home And Work

- According to our research, the average time spent playing video games will increase from 1.1 hours per person per day to 1.5 hours during the next five years.
- If the increasing trend of both monetization and time spent remains in place, in-game purchase revenue could compound 21% annually during the next five years, from roughly \$130 billion in 2020 to nearly \$350 billion by 2025.

Global Virtual Gaming Revenue (Forecast)



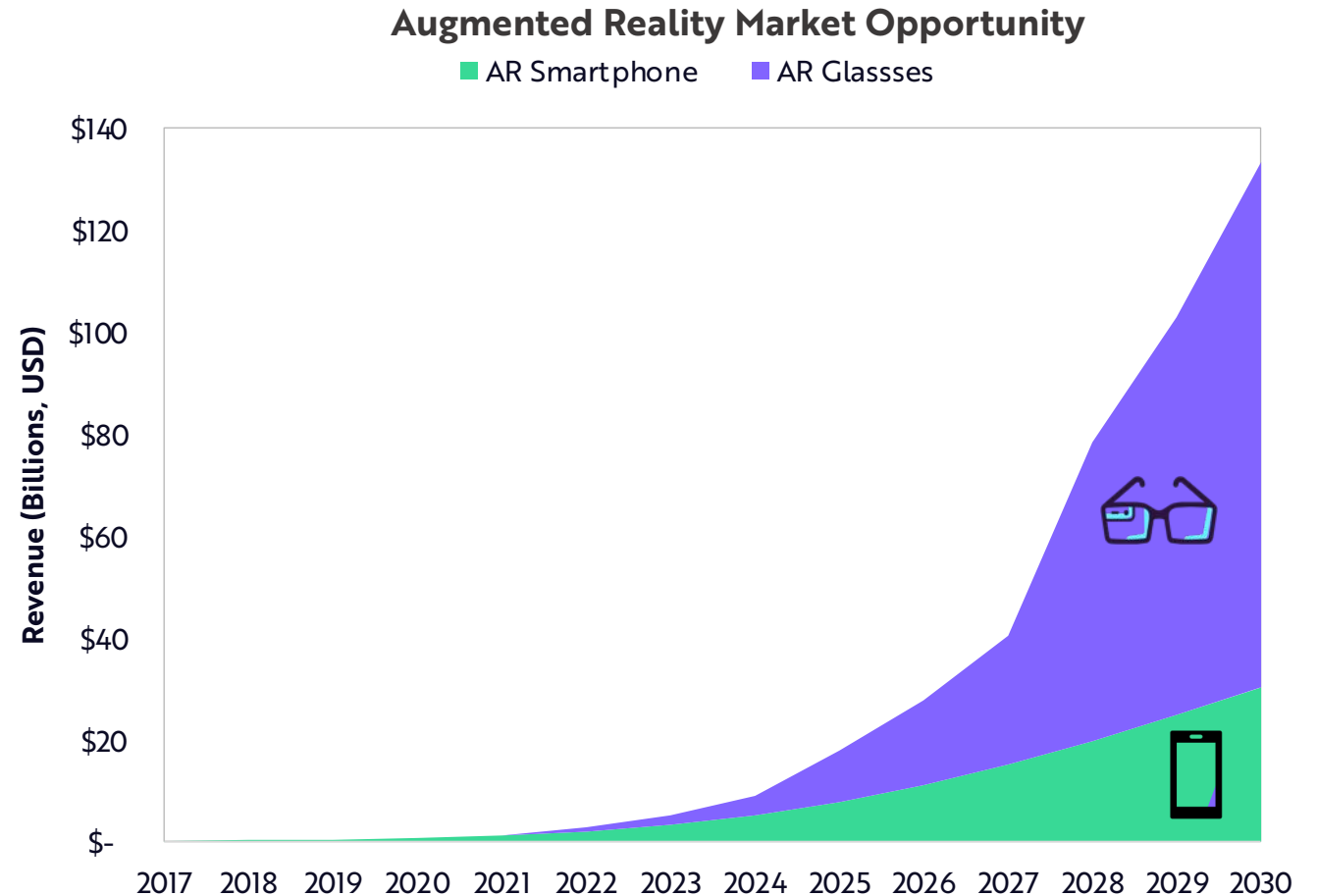
Forecasts are inherently limited and cannot be relied upon.

Source: ARK Investment Management LLC based on data sourced from: "Newzoo Global Mobile Market Report 2020: Free Version." Newzoo, 30 Sept. 2020, newzoo.com/insights/trend-reports/newzoo-global-mobile-market-report-2020-free-version/.



Augmented Reality (AR) Is Primed To Scale

- Over the past few years, companies such as Snapchat, Facebook, and Apple have increased their investment in augmented reality, encouraging widespread use of AR tools on mobile devices.
- By 2022, consumer-grade AR headsets should turbocharge this trend.
- ARK forecasts that by 2030 the AR market could scale from under a \$1 billion today to \$130 billion.¹



[1] ARK's AR market size estimates consumer-based software revenues and does not include gaming or commercial revenue. AR gaming revenue is captured in our gaming forecast. Forecasts are inherently limited and cannot be relied upon.

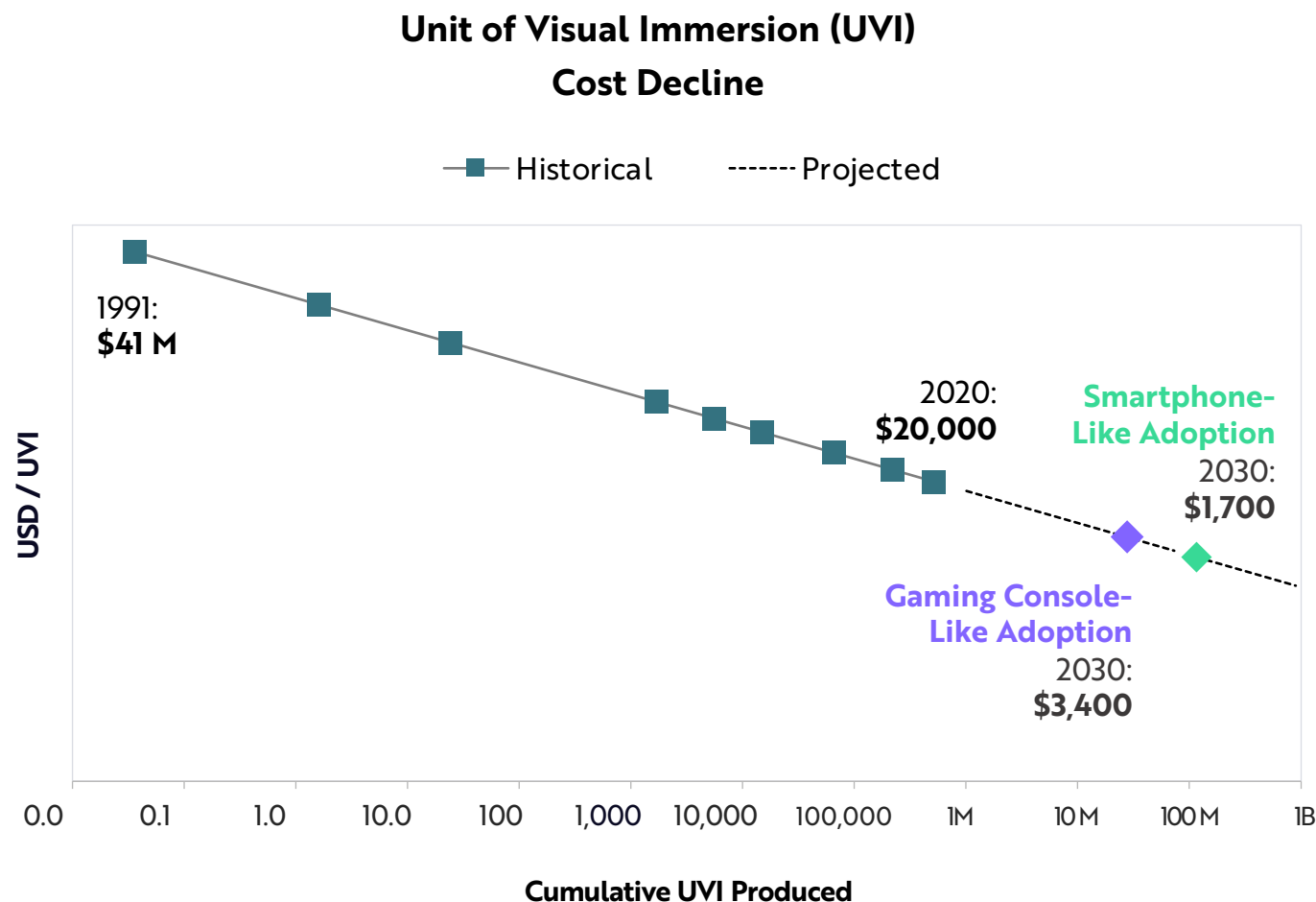
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Source: ARK Investment Management LLC based on data sourced from: O'Dea, Published by S., and Aug 20. "Smartphone Users Worldwide 2020." Statista, 20 Aug. 2020, www.statista.com/statistics/330695/number-of-smartphone-users-worldwide/; Boland, Mike. "AR Advertising: \$2.6 Billion by 2022." AR Insider, 6 Sept. 2018, arinsider.co/2018/09/04/ar-advertising-2-6-billion-by-2022/.



"Virtual Reality" Could Approach Reality By 2030

- Based on our proprietary scoring system (UVI), best in class VR headsets today achieve only 10% of human visual immersion.
- If consumer VR is limited to the console gaming market, we believe VR headsets will not scale to human immersion capabilities for the mass market.
- Based on Wright's Law,² complete visual immersion at a price-point comparable to that of a PC will require VR headsets to follow the adoption curve of smart-phones until 2030.



[1] Unit of Visual Immersion is calculated by taking the harmonic mean of Resolution, Refresh Rate, and Field of View per device divided by estimated max Resolution, Refresh Rate, and Field of View respectfully, with each factor weighted differently. [2] Pioneered by Theodore Wright in 1936, Wright's Law aims to provide a reliable framework for forecasting cost declines as a function of cumulative production. Specifically, it states that for every cumulative doubling of units produced, costs will fall by a constant percentage.

Forecasts are inherently limited and cannot be relied upon.

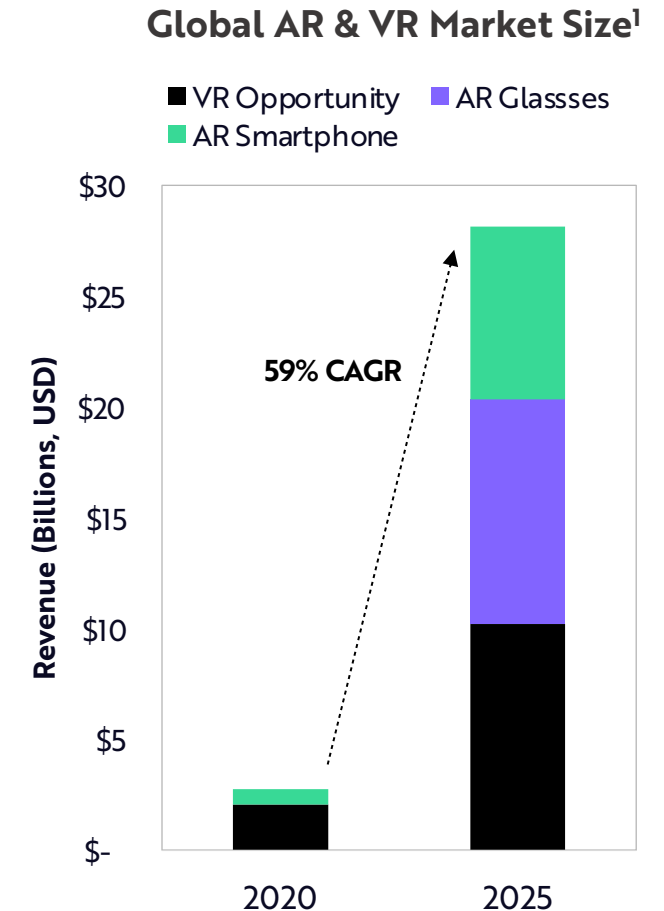
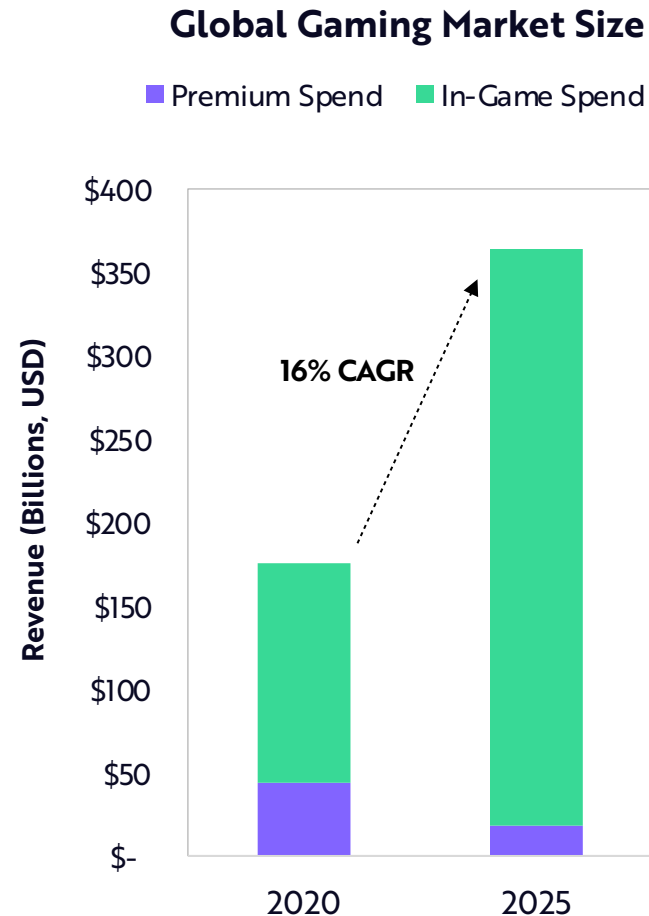
Source: ARK Investment Management LLC based on data sourced from: S&P Global Market Intelligence.



SIZING THE OPPORTUNITY

The Revenue From Virtual Worlds Could Approach \$400 Billion By 2025.

- Based on our research, the global gaming market will increase at a 16% compound annual rate during the next five years, from \$175 billion in 2020 to roughly \$365 billion by 2025.
- The AR & VR markets will grow at a 59% compound annual rate during the next five years, from \$3 billion to \$28 billion in 2025.**



[1] ARK's AR & VR market size is an estimate of consumer-based software revenues. Forecasts are inherently limited and cannot be relied upon.

Source: ARK Investment Management LLC based on data sourced from: "O'Dea, Published by S., and Aug 20. "Smartphone Users Worldwide 2020." Statista, 20 Aug. 2020, www.statista.com/statistics/330695/number-of-smartphone-users-worldwide/; Boland, Mike. "AR Advertising: \$2.6 Billion by 2022." AR Insider, 6 Sept. 2018, arinsider.co/2018/09/04/ar-advertising-2-6-billion-by-2022/; Platform.marketintelligence.spglobal.com, platform.marketintelligence.spglobal.com/web/client?auth=inherit; "Newzoo Global Mobile Market Report 2020: Free Version." Newzoo, 30 Sept. 2020, newzoo.com/insights/trend-reports/newzoo-global-mobile-market-report-2020-free-version/.



Digital Wallets

Digital Wallets Represent A \$4.6 Trillion Opportunity In Your Pocket

- We believe Venmo, Cash App, and venture funded startups are likely to upend traditional banking by activating the mobile phones — the bank branches — in users' pockets and handbags.
- Today, digital wallets are beginning to penetrate the full traditional financial services stack, including brokerage and lending. Digital wallets could serve as lead generation platforms for commercial activity beyond financial products.
- **According to ARK's research, digital wallets are valued between \$250 and \$1,900 per user today but could scale to \$20,000 per user, representing a \$4.6 trillion opportunity in the US by 2025.**

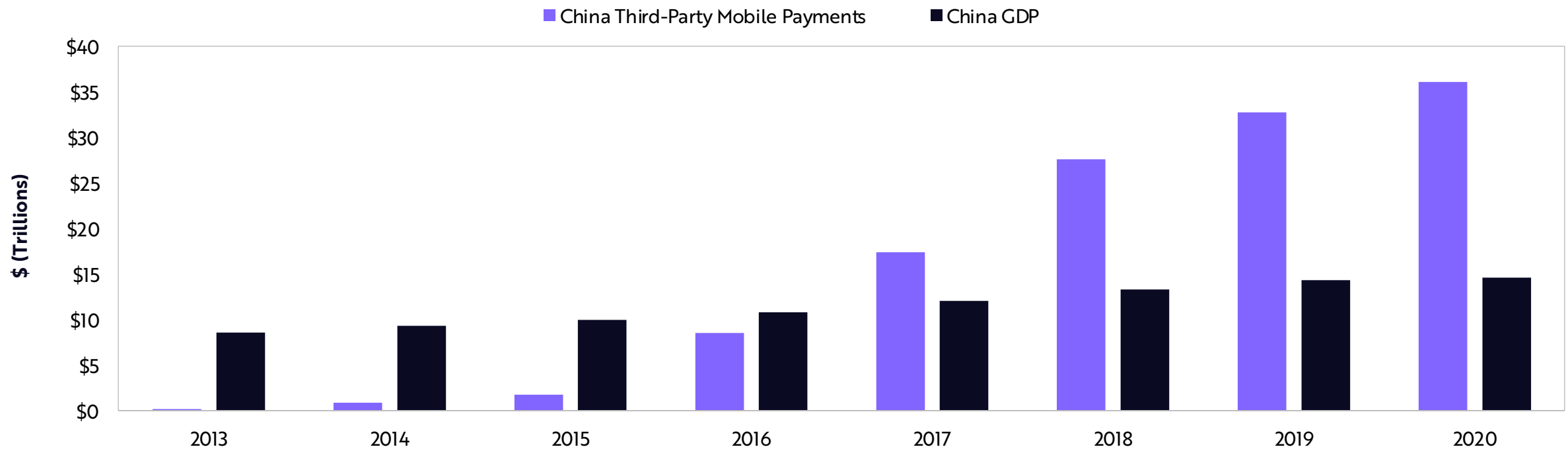
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Incubated In China, Mobile Payments Are 2.5x Its GDP

The volume of mobile payments in China has exploded more than 15-fold in just five years, from roughly \$2 trillion in 2015 to an estimated \$36 trillion, nearly three times the size of China's GDP in 2020.

China Third Party Mobile Payments vs. China GDP

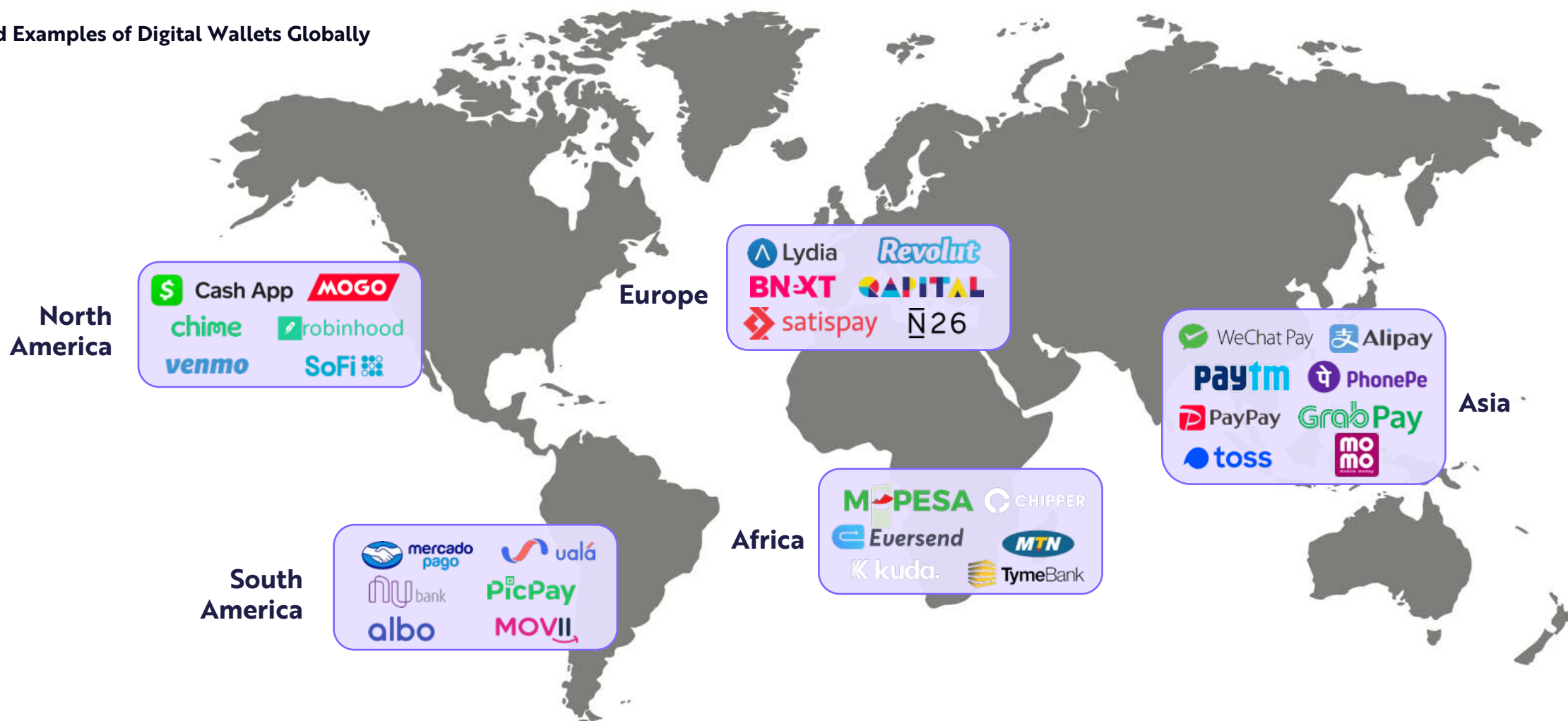


Source: ARK Investment Management LLC, 2020 based on data sourced from: "2020 China Third-Party Payment Industry Report", iresearch.com.cn, iResearch; "GDP – China", worldbank.org, World Bank; "World Economic Outlook, October 2020: A Long and Difficult Ascent", imf.org, International Monetary Fund (IMF).



Digital Wallets Have Become A Global Phenomenon

Selected Examples of Digital Wallets Globally

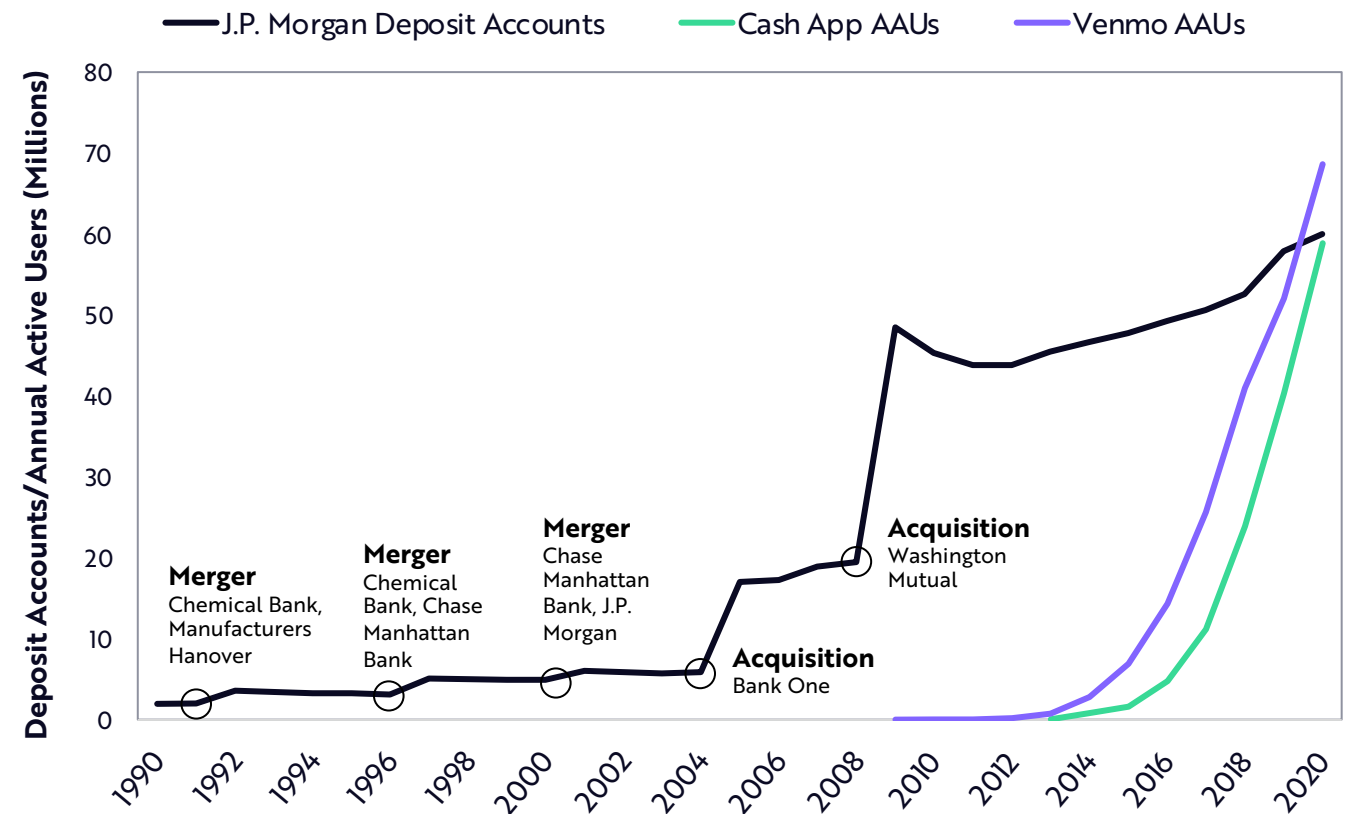




In The US, Digital Wallet Users Are Surpassing The Number Of Deposit Account Holders At The Largest Financial Institutions

- Square's Cash App and PayPal's Venmo each amassed roughly 60 million active users organically in the last 7 and 10 years, respectively, a milestone that took J.P. Morgan more than 30 years and five acquisitions to reach.
- At the end of 2020, the number of J.P. Morgan Chase deposit account holders totaled approximately 60 million¹ while Cash App's and Venmo's Annual Active Users (AAUs) scaled to 59 million and 69 million, respectively.

J.P. Morgan Chase Deposit Accounts vs. Cash App and Venmo
Annual Active Users (AAUs)



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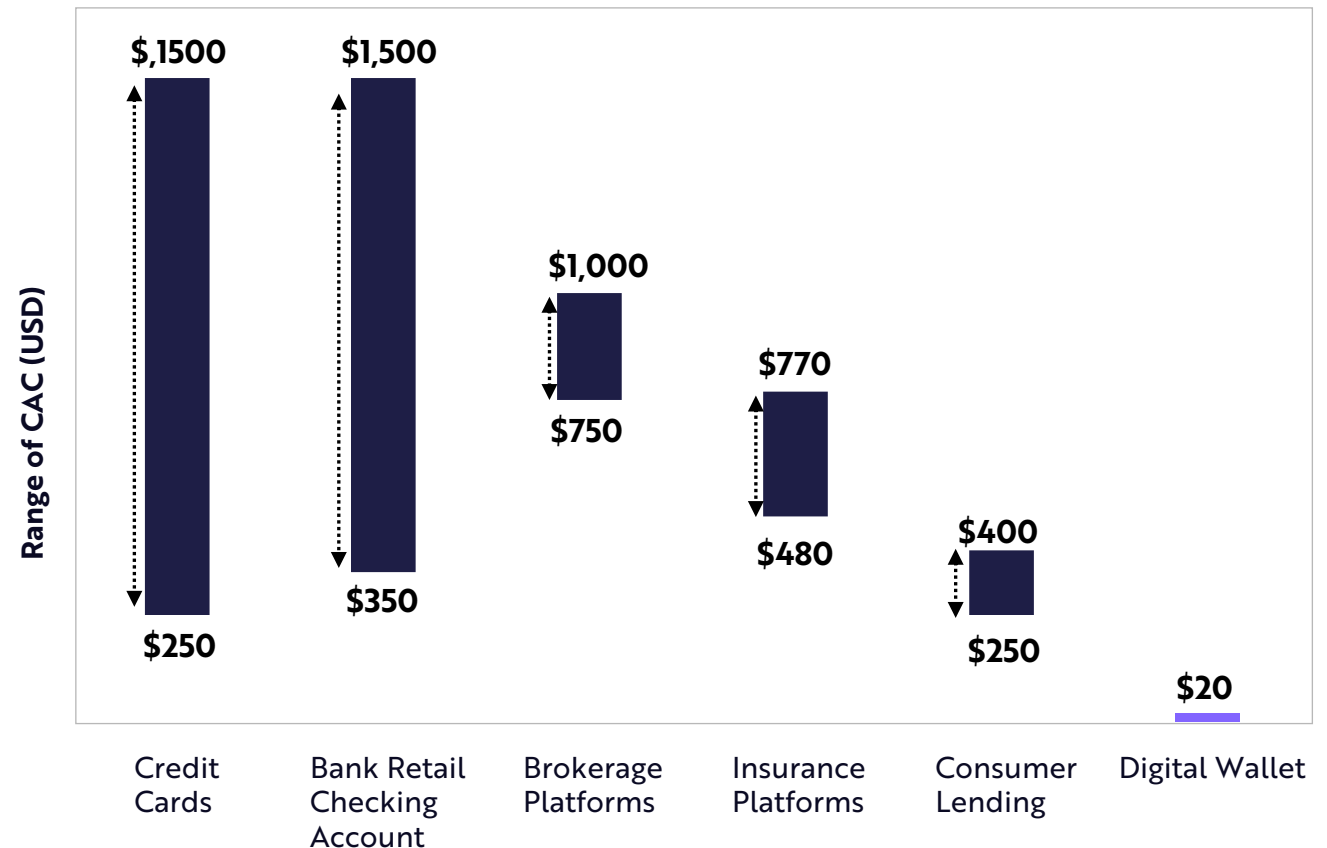
[1] Refers to number of J.P. Morgan Chase deposit accounts <\$100,000 prior to 2010 and number of deposit accounts <\$250,000 after 2010 due to changing reporting regulation. Source: ARK Investment Management LLC, 2020 based on data sourced from: Federal Deposit Insurance Corporation (FDIC) Statistics on Depository Institutions (SDI) and RIS.



Digital Wallets Can Acquire Customers For A Fraction Of Banks' Customer Acquisition Costs

- A primary driver of the explosive growth in digital wallets is lower customer acquisition costs.
- According to ARK's research, compared to the roughly \$1,000 that a traditional financial institution might pay to acquire a new checking account customer, digital wallets invest only \$20 thanks to viral peer-to-peer payment ecosystems, savvy marketing strategies, and dramatically lower cost structures.¹

Customer Acquisition Costs (CAC) Across Financial Products

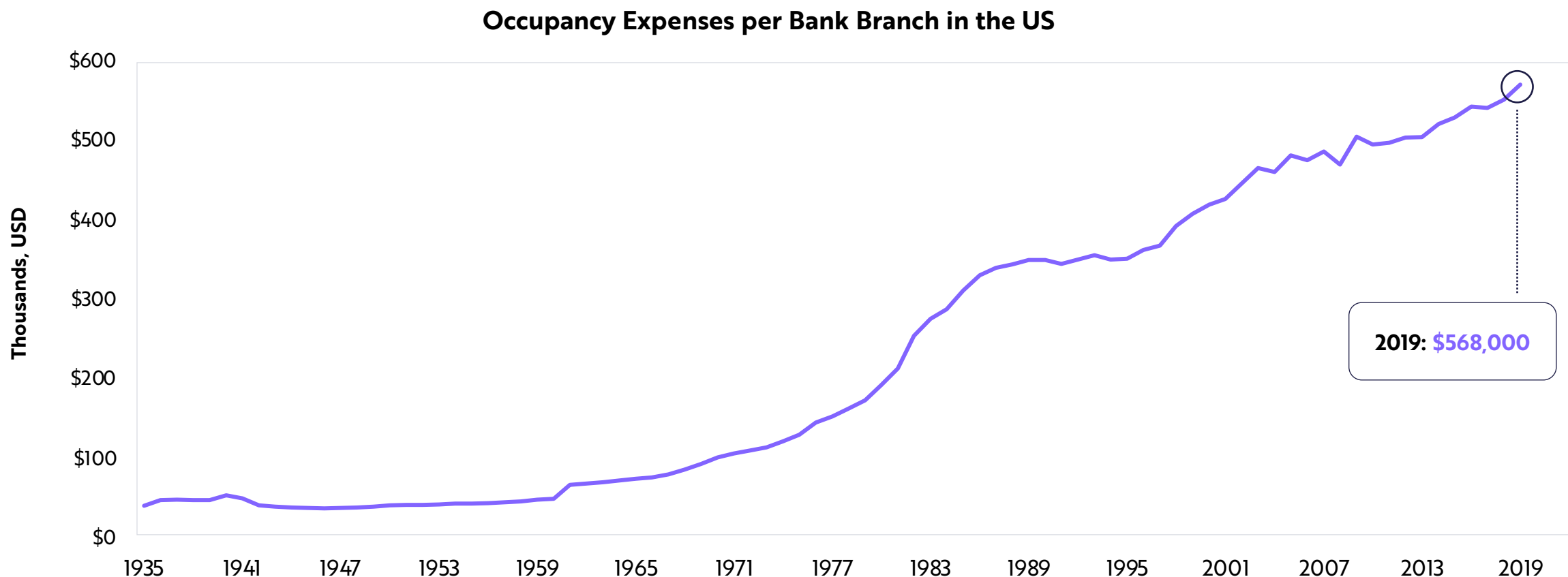


[1] "Cash App vs. Venmo: Research White Paper by ARK Invest." ARK Invest, 4 May 2020, ark-invest.com/white-papers/cash-app-vs-venmo/.
Source: ARK Investment Management LLC, 2020



Bank Branch Costs Are Rising While Their Utility Is Decreasing

As consumers have abandoned bricks & mortar in favor of mobile banking, bank branches have experienced increased occupancy expenses, which hit a record high of \$568,000 in 2019.

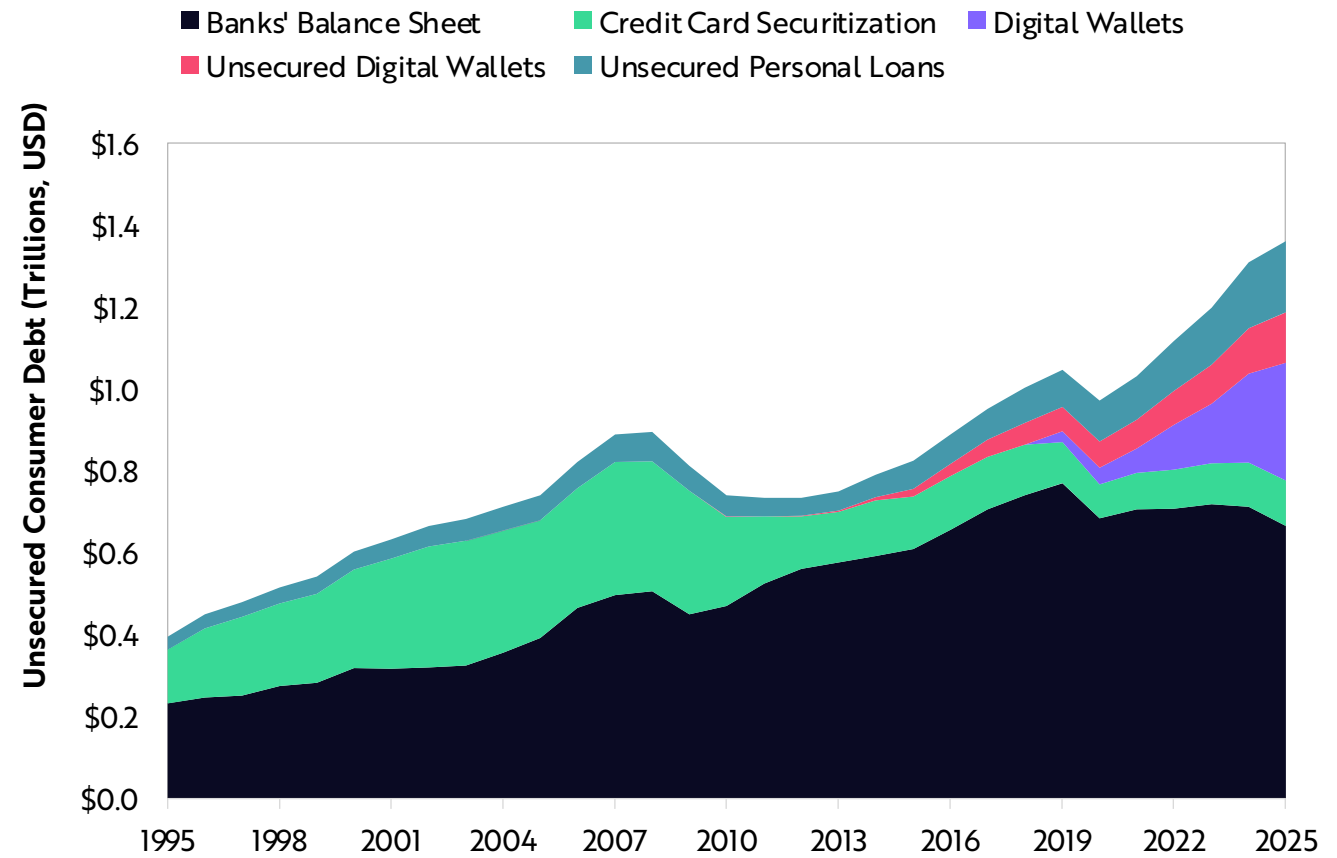




Traditional Banks Are Facing Potentially Sizeable Risks

- Digital wallets are entering the unsecured lending market, suggesting that traditional bank lending is unlikely to recover to the peak hit in 2019.
- According to ARK estimates, bank interest income on credit cards fell more than 10%, or roughly \$16 billion in 2020 and is likely to drop more than 25% further, from \$130 billion in 2019 to \$95 billion by 2025.
- Digital lenders such as Square, PayPal, Affirm, Klarna and LendingClub are likely to take share from traditional banks.

Total Unsecured Consumer Debt in the US



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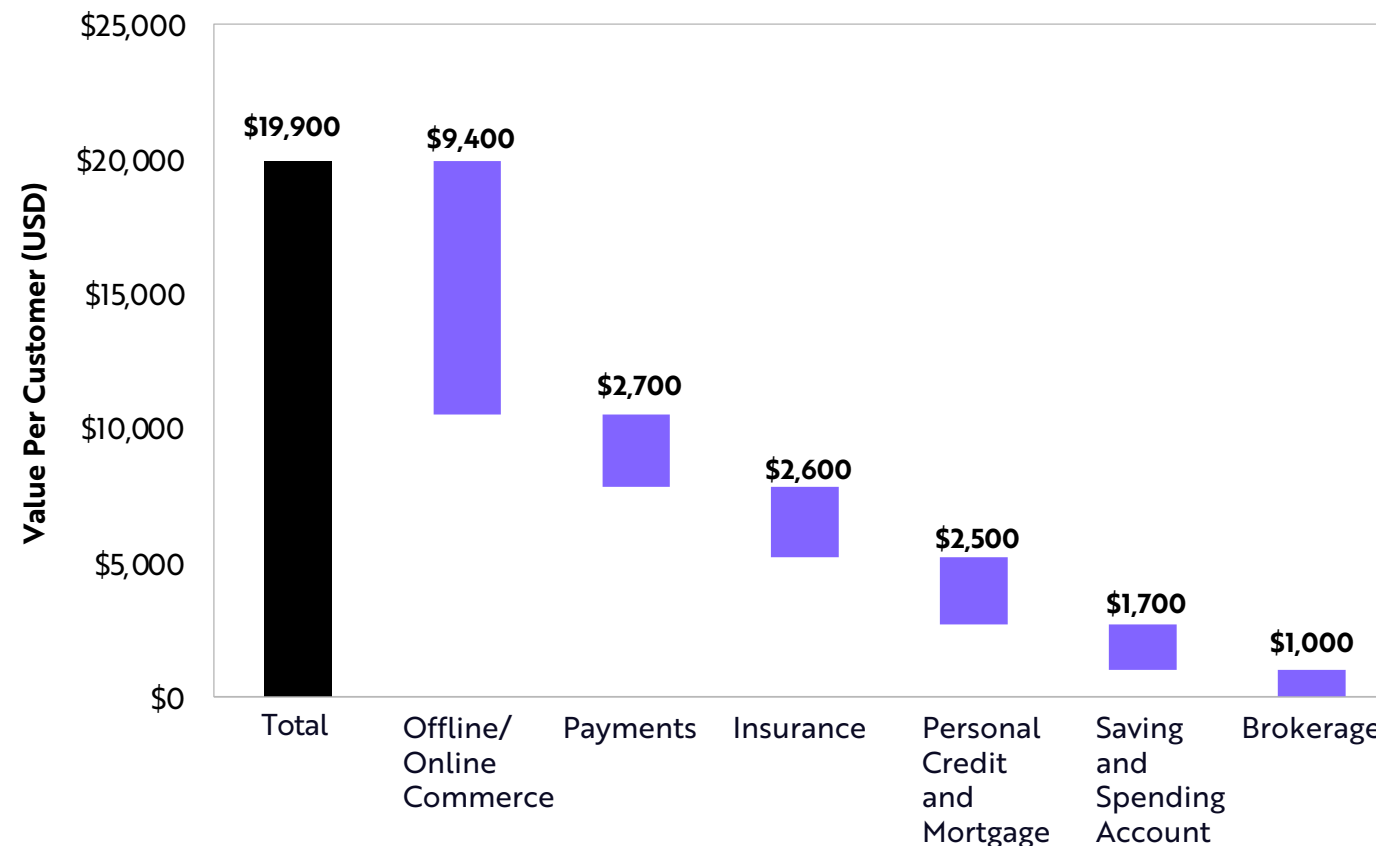
Source: ARK Investment Management LLC, 2020 based on data sourced from: "US ABS Issuance and Outstanding." Securities Industry and Financial Markets Association, 6 Nov. 2020, <https://www.sifma.org/resources/research/us-abs-issuance-and-outstanding/>; "Board of Governors of the Federal Reserve System." The Fed - Consumer Credit - G.19, https://www.federalreserve.gov/releases/g19/hist/cc_hist_sa_levels.html; "Consumer Credit Market Withstands Challenges as Accounts in Financial Hardship Begin to Decrease." Transunion.Com, 20 Aug. 2020, newsroom.transunion.com/consumer-credit-market-withstands-challenges--as-accounts-in-financial-hardship-begin-to-decrease.



At Maturity, Each Digital Wallet User Could Be Worth Roughly \$20,000

- If digital wallets were to become consumer financial dashboards, ARK estimates that the net present value associated with their financial service revenues will exceed \$10,000 per average US user.
- Beyond financial services, digital wallets could become lead generation platforms for offline and online commerce, potentially adding another \$9,000-\$10,000 to the net present value of their revenues.

Potential Value Per Average Digital Wallet Customer Across Commercial and Financial Products in the US



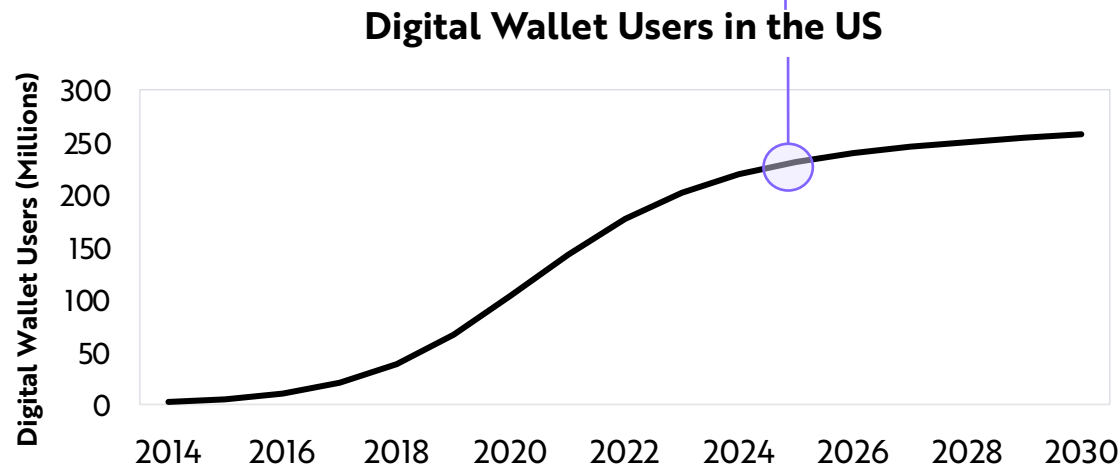
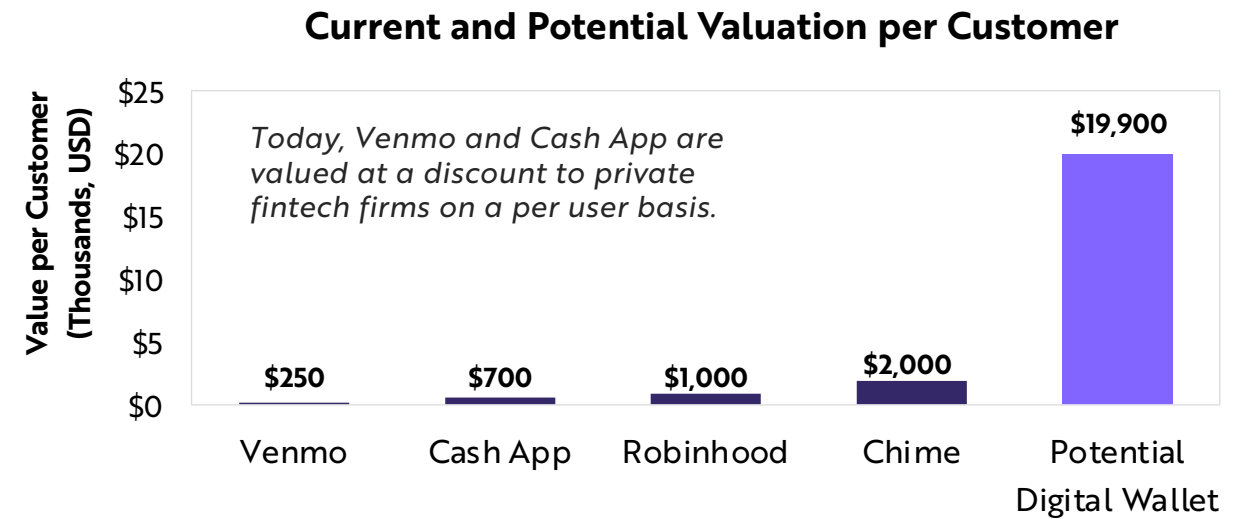
Forecasts are inherently limited and cannot be relied upon.

Source: ARK Investment Management LLC, 2020 based on data sourced from: Offline/Online Commerce assumes digital wallet captures 5% lead generation fee for 100% of offline and online average US consumer retail spend. Insurance assumes digital wallet captures 10% lead generation fee of average insurance revenue per US consumer. Saving and Spending Account assumes digital wallet captures spread between interest and risk-free rate for average balance of US transaction accounts as defined by the Federal Reserve. Offline and Online Payments assumes digital wallet captures fee standard exempt debit interchange revenue of 100% of offline and online average US consumer retail spend. Personal credit assumes 6% revenue yield on average consumer debt of US consumer. Mortgage assumes 10% lead generation fee on average revenue per mortgage per average US consumer. Brokerage assumes digital wallet captures net interest and fees (excluding commissions) revenue from average US brokerage consumer.



SIZING THE OPPORTUNITY

According to ARK's research, if each of the estimated 230 million US digital wallet users were valued at \$19,900 in 2025, the US digital wallet opportunity would be worth \$4.6 trillion.

230 Million Digital Wallet Users by 2025**X****\$19,900 Potential Value per Customer**

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Source: ARK Investment Management LLC, 2020. ARK's estimate of PayPal's and Square's market capitalization is attributable to each estimated monthly active Venmo and Cash App user, respectively. ARK's estimate of Robinhood's and Chime's most recent post-money valuation is attributable to each estimated monthly active Robinhood and Chime user, respectively. For \$19,900 potential digital wallet value per customer, see sourcing on prior slide.



Bitcoin's Fundamentals

The Price Of Bitcoin Has Hit An All-Time High, Supported By Robust Network Fundamentals

- As bitcoin's price hit an all-time high, ARK's research indicated that its network fundamentals remained healthy.
- Based on search volumes compared to 2017, bitcoin's price increase seems to be driven less by hype. With bitcoin appearing to gain more trust, some companies are considering it as cash on their balance sheets.
- **If all S&P 500 companies were to allocate 1% of their cash to bitcoin, ARK estimates that its price would increase by approximately \$40,000.**

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As Support For Its Network Increased, Bitcoin's Price Hit An All-time High In Late 2020

Bitcoin's Price in 2020, USD



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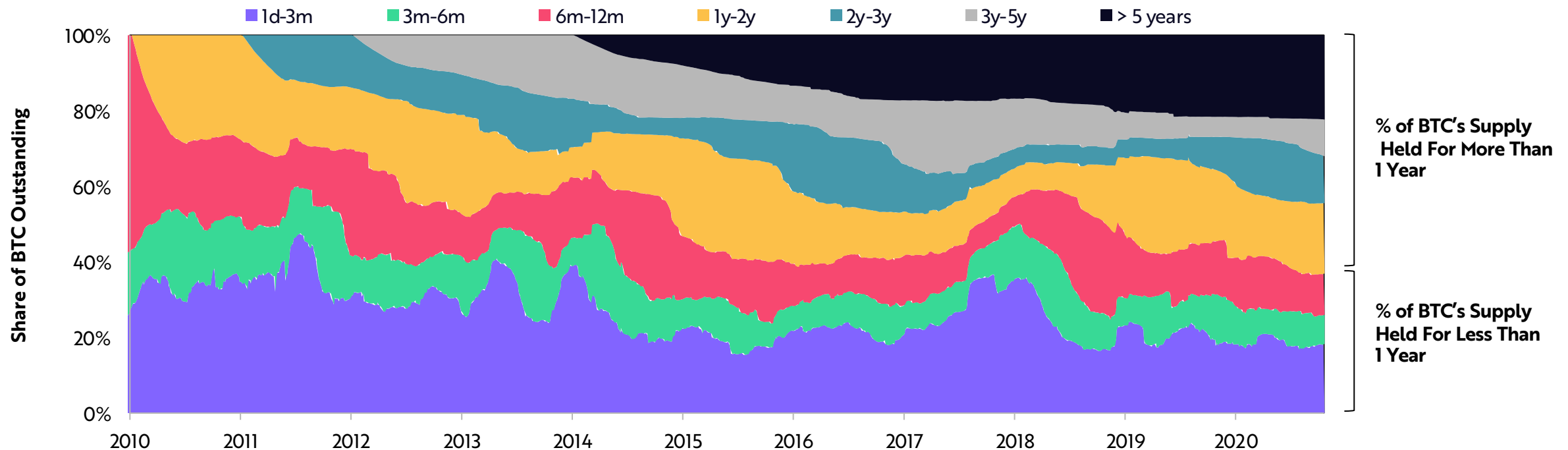
Source: ARK Investment Management LLC, 2020 based on data sourced from: PlusToken, "GBTC Now Holds More than 285,000 Bitcoin, 1.57% of All Bitcoin," The Block, 10 Feb. 2020, www.theblockcrypto.com/genesis/55363/gbtc-now-holds-more-than-285000-bitcoin-1-57-of-all-btc; Partz, Helen. "It Happened: Bitcoin Just Experienced Third Halving in Its History." Cointelegraph, Cointelegraph, 11 May 2020, cointelegraph.com/news/it-happened-bitcoin-just-experienced-third-halving-in-its-history; Microstragy Earnings Report; Kapilkov, Michael. "Jack Dorsey's Square Adds 4,709 Bitcoin to Its Balance Sheet." Cointelegraph, 8 Oct. 2020, cointelegraph.com/news/jack-dorsey-s-square-adds-4-709-bitcoin-to-its-balance-sheet; "PayPal Launches New Service Enabling Users to Buy, Hold and Sell Cryptocurrency." PayPal Newsroom, newsroom.paypal-corp.com/2020-10-21-PayPal-Launches-New-Service-Enabling-Users-to-Buy-Hold-and-Sell-Cryptocurrency.



Bitcoin's Market Participants Never Have Been More Long-Term Focused

As of November 2020, roughly 60% of bitcoin's supply had not moved in more than a year, a testament to the market's longer-term focus and a holder base with stronger conviction.

Bitcoin "HODL" Waves



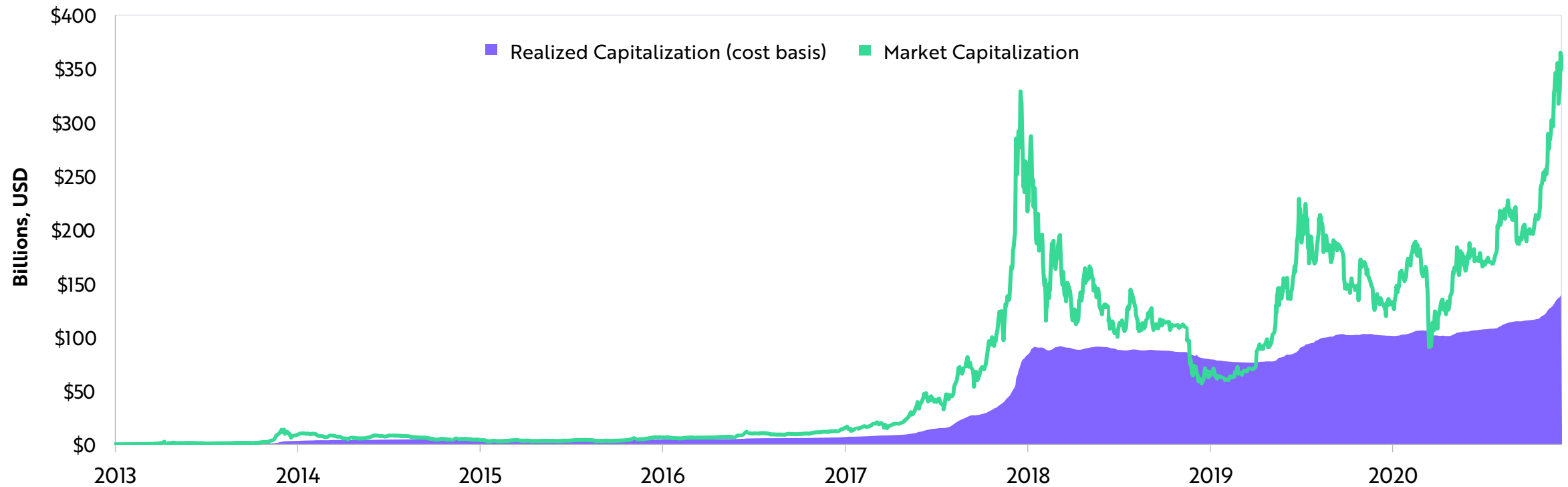
Note: HODL is slang in the cryptocurrency community for holding the cryptocurrency rather than selling it.
For informational purposes only and should not be considered investment advice, or a recommendation to buy, sell or hold any particular security or cryptocurrency.
Source: ARK Investment Management LLC, 2020 based on data sourced from: Glassnode



Bitcoin's Market And Investor Set Appear To Be Maturing

Bitcoin's Realized Capitalization, a measure of a holder's cost basis, has hit an all-time high.¹ A growing cost basis suggests that early investors are taking profits, while newer investors are establishing positions and creating higher price support levels.

Bitcoin's Aggregate Cost Basis Hit New Records In 2020



As of December 2020.

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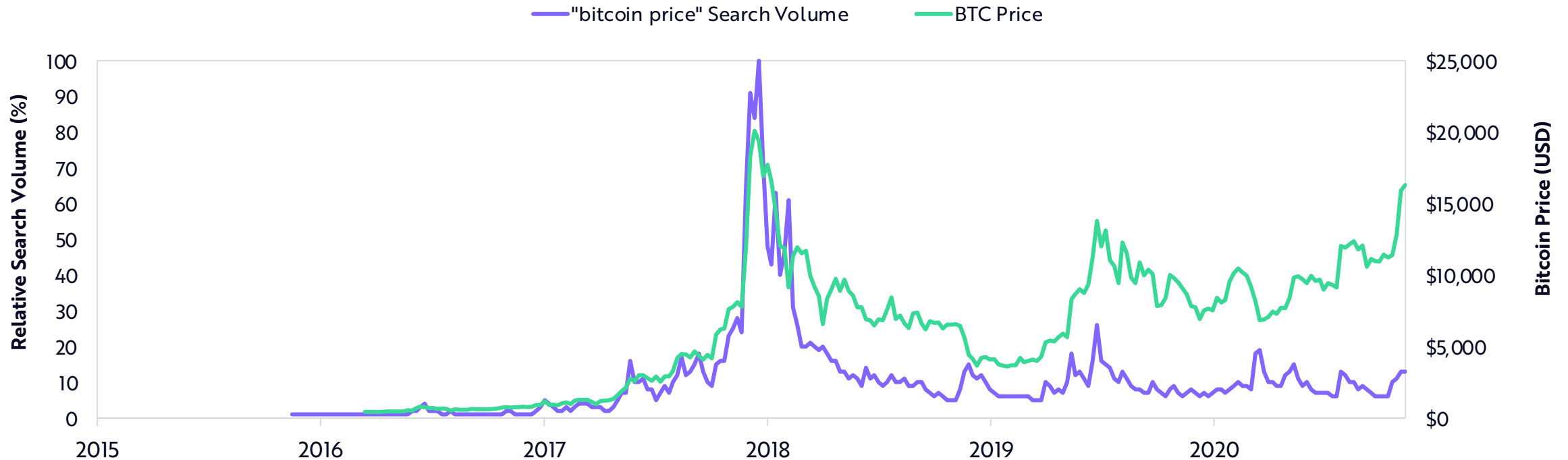
Source: ARK Investment Management LLC, 2020 based on data sourced from: Coinmetrics



Compared To 2017, The Hype Around Bitcoin Appears Contained

Bitcoin's search interest is low relative to the increase in its price. As its price neared all-time highs, bitcoin's Google search interest was at 15% of its all-time high.

Bitcoin Price vs. "bitcoin price" Search Volume

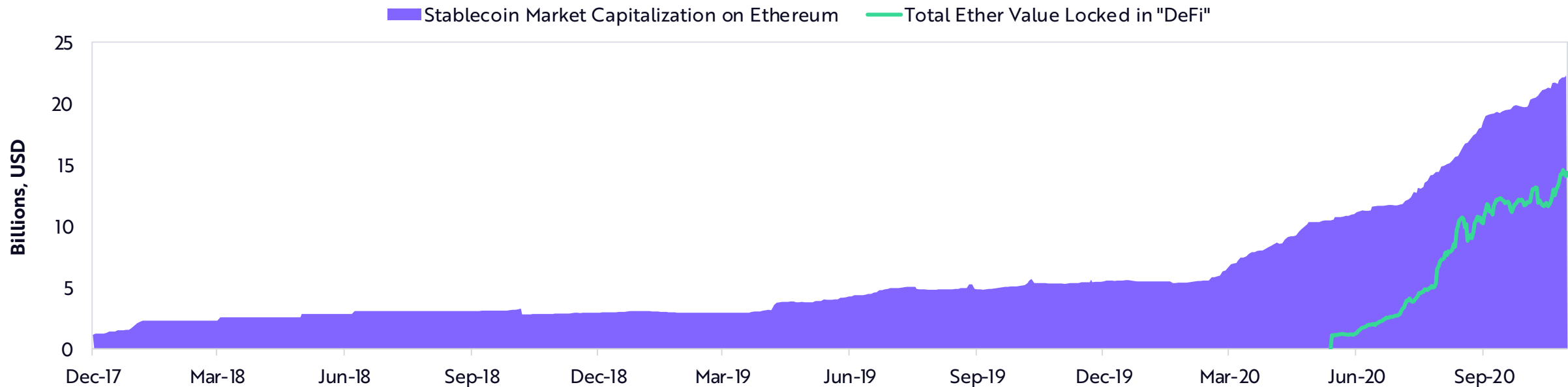




Bitcoin's Increasing Acceptance Has Set The Stage For Ethereum And A New Wave Of Financial Experimentation

We believe that decentralized finance ("DeFi") has been a positive catalyst for the increased adoption of Ethereum's network. By leveraging ether as "trust-minimized" collateral, market participants can disintermediate traditional financial companies and access financial services like credit & lending, market making, trading, custody, investing, and access to synthetic US dollar exposure.

Financial Experimentation On The Ethereum Network



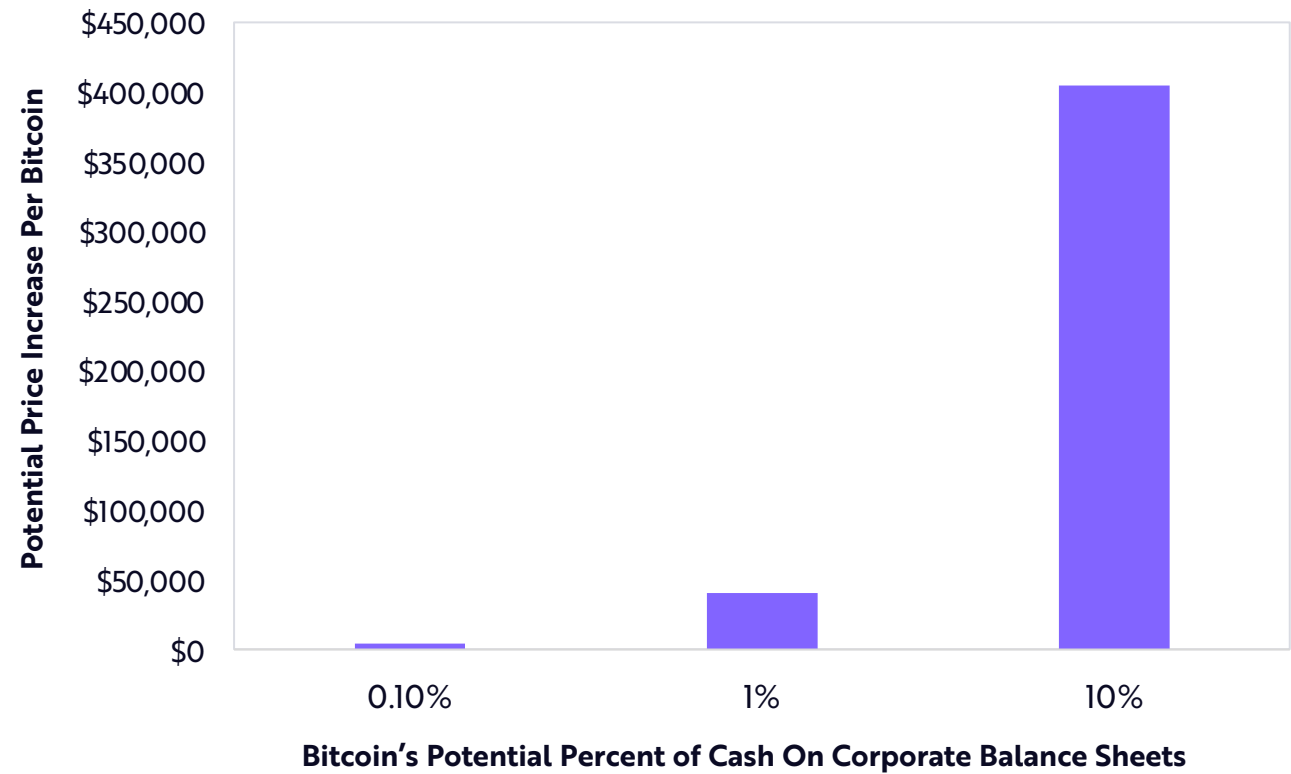


SIZING THE OPPORTUNITY

Bitcoin Could Play A Pivotal Role As Corporate Cash.

- Square and Microstrategy, both with balance sheet investments in bitcoin, are showing the way for public companies to deploy bitcoin as a legitimate alternative to cash.
- **According to our research, if all S&P 500 companies were to allocate 1% of their cash to bitcoin,¹ its price could increase by approximately \$40,000.**

Hypothetical Price Increase If Bitcoin Were to Replace Cash on S&P 500 Corporate Balance Sheets



[1] As of December 1, 2020

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Source: ARK Investment Management LLC, 2020



Bitcoin: Preparing For Institutions

ARK Believes Bitcoin's Rapid Growth Has Positioned It For An Allocation In Investment Portfolios

- We believe bitcoin offers one of the most compelling risk-reward profiles among assets.
- As our analysis suggests, it could scale from roughly \$500 billion¹ to \$1-5 trillion in network capitalization during the next five to ten years.
- In our view, capital allocators should consider the opportunity cost of ignoring bitcoin as part of a new asset class.

06

[1] As of December 31, 2020

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Bitcoin Continues To Gain Credibility

Entity	Market Validation
Regulators	- OCC permits federally chartered banks and thrifts to provide custody services for cryptoassets (6/22/2020) - OCC permits national banks and federal savings associations to hold "reserves" on behalf of customers who issue stablecoins (9/21/2020) - OCC permits banks to run nodes on public blockchain networks to streamline payment functions like processing, validation, and settlement. (1/4/21)
Banks	- JP Morgan adds major cryptocurrency exchanges Coinbase and Gemini as banking clients (5/12/2020) - Singapore's largest bank, DBS, announces plans to launch a cryptocurrency exchange (10/27/2020) - Kraken becomes first cryptocurrency exchange to charter a US bank (9/16/2020)
Institutional Investors	- Macro investor Paul Tudor Jones discloses a 1% allocation to bitcoin (5/11/2020) - Billionaire Stanley Druckenmiller places a bet on bitcoin (11/17/2020) - Fidelity Digital to hold bitcoin as collateral for cash loans (12/9/20) - Insurance giant MassMutual invests \$100 million into bitcoin (12/10/20)
Public Companies	- MicroStrategy substitutes its \$500 million in cash for bitcoin (7/20/2020) - Square invests 1% of its assets in bitcoin (10/8/2020) - PayPal announces cryptocurrency buying and selling services (10/20/2020)

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, 2020 based on data sourced from: PTJ: <https://www.cnn.com/2020/05/11/paul-tudor-jones-calls-bitcoin-a-great-speculation-says-he-has-almost-2percent-of-his-assets-in-it.html>
 Druckenmiller: <https://www.theblockcrypto.com/linked/84069/stanley-druckenmiller-bitcoin-bet> Salinas: <https://www.forbes.com/sites/billybambrough/2020/11/20/mexican-billionaire-reveals-government-fears-sparked-bitcoin-investment/?sh=5e7c7ecc258d> OCC crypto custody: <https://www.occ.gov/news-issuances/news-releases/2020/nr-occ-2020-98.html> OCC stablecoin: <https://www.occ.gov/news-issuances/news-releases/2020/nr-occ-2020-125.html> JP Morgan: <https://www.coindesk.com/coinbase-gemini-first-crypto-exchange-customers-jpmorgan-bank-report> Singapore DBS: <https://www.theblockcrypto.com/post/82411/singapore-biggest-bank-dbs-crypto-exchange> Kraken: <https://www.coindesk.com/kraken-crypto-exchange-secures-bank-charter-under-wyoming-law> Microstrategy: <https://news.bitcoin.com/nasdaq-microstrategy-bitcoin-425-million/> Square: <https://www.coindesk.com/square-buys-50m-in-bitcoin> PayPal: <https://newsroom.paypal-corp.com/2020-10-21-PayPal-Launches-New-Service-Enabling-Users-to-Buy-Hold-and-Sell-Cryptocurrency>



ARK Believes Bitcoin Deserves A Strategic Allocation In Institutional Portfolios

Untethered from traditional rules and regulations and generally uncorrelated to the behavior of other asset classes, bitcoin seems to have earned a strategic allocation in well-diversified portfolios. During the past decade, bitcoin is the only major asset with consistently low correlations to traditional asset classes.

Correlation Matrix

- High correlation: coefficient value lies between ± 0.50 and ± 1
- Moderate correlation: coefficient value lies between ± 0.30 and ± 0.49
- Low correlation: coefficient value lies below $\pm .29$

	Bitcoin	S&P 500	Bonds	Gold	Oil	Emerging Market Currencies	Real Estate	TSLA	AAPL	BAC
Bitcoin		0.26	-0.14	0.24	0.19	0.13	0.34	0.15	0.17	0.25
S&P 500	0.26		-0.62	0.37	0.59	0.52	0.89	0.51	0.69	0.89
Bonds	-0.14	-0.62		0.61	-0.44	-0.36	-0.49	-0.30	-0.29	-0.61
Gold	0.24	0.37	0.61		0.43	0.37	0.26	0.22	-0.22	-0.55
Oil	0.19	0.59	-0.44	0.43		0.53	0.48	0.42	0.37	0.53
Emerging Market Currencies	0.13	0.52	-0.36	0.37	0.53		0.45	0.29	-0.22	0.42
Real Estate	0.34	0.89	-0.49	0.26	0.48	0.45		0.47	0.57	0.77
TSLA	0.15	0.51	-0.30	0.22	0.42	0.29	0.47		0.40	0.42
AAPL	0.17	0.69	-0.29	-0.22	0.37	-0.22	0.57	0.40		0.49
BAC	0.25	0.89	-0.61	-0.55	0.53	0.42	0.77	0.42	0.49	

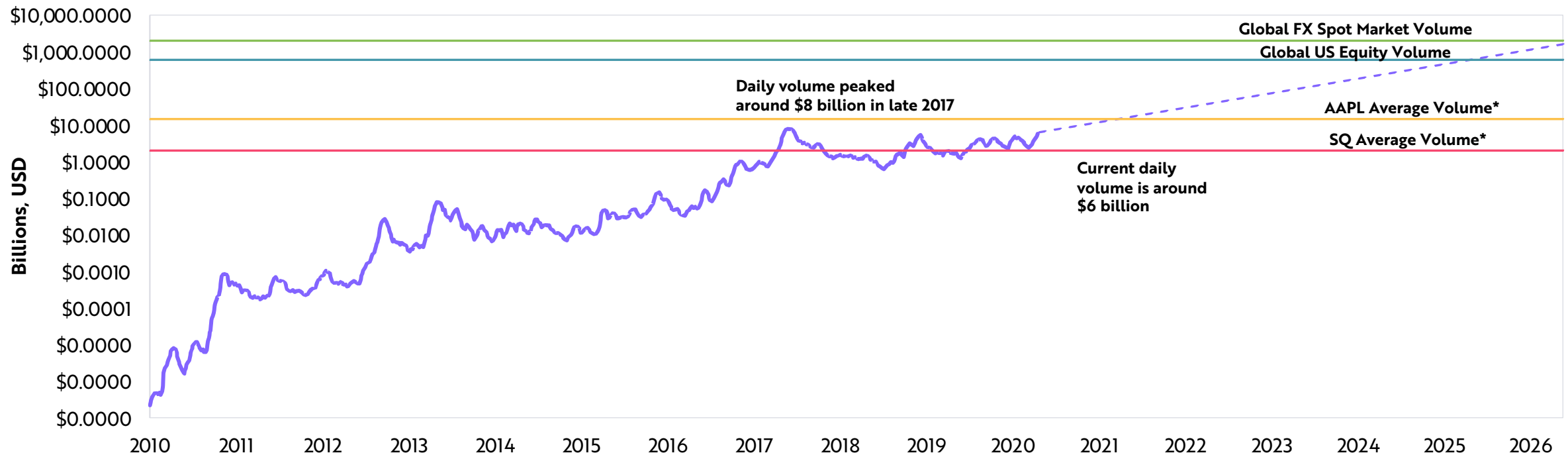
Note: TSLA, AAPL, and BAC are included because bitcoin most closely resembles a large cap stock in its volume and liquidity profile but presents a different risk-reward profile. For informational purposes only and should not be considered investment advice, or a recommendation to buy, sell or hold any particular security or cryptocurrency. | Source: ARK Investment Management LLC, 2020 based on data sourced from: Bloomberg. Methodology: We take the maximum - positive or negative - one-year rolling correlation of listed assets since 2011. Our correlation calculation uses a Pearson correlation of logarithmic price returns. To take the correlation, we selected the following commonly used asset class benchmarks: Real Estate - The Morgan Stanley Capital International (MSCI), US Real Estate Investment Trust Index (RMZ), Commodities - The Crude Oil Futures (CL1 COMB), Currencies - MSCI Global Currency Index, Bonds - Bloomberg Barclays US Aggregate Bond Index, Equities - S&P 500, Gold - GLD.



Bitcoin Trading Volume Is Comparable To That Of A Large Cap Stock And Has Grown At An Exponential Rate

ARK estimates that bitcoin's daily trading volume could exceed the volume of the US equity market in fewer than four years and the volume of the global FX spot market in fewer than six years.

Bitcoin Spot Market US Dollar Daily Volume On Major Exchanges



*Securities referenced are provided as examples of large capitalization stock average volume. The static lines are the average 2020 trading volume of each of those stocks.

Forecasts are inherently limited and cannot be relied upon.

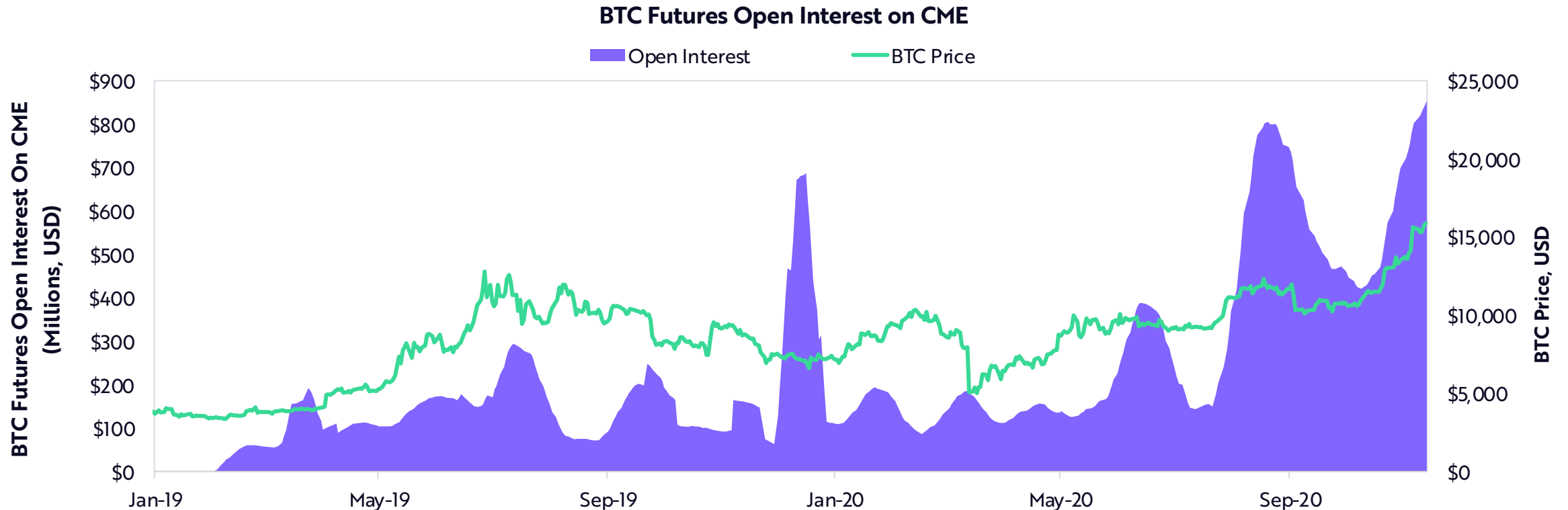
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Source: ARK Investment Management LLC, 2020 based on data sourced from: Coinmetrics



Institutional Investors Can Access Bitcoin In Sophisticated Ways

Bitcoin open interest, or the total outstanding value of futures contracts, hit an all-time high on the Chicago Mercantile Exchange (CME) in October 2020. It increased 10-fold and hit nearly \$1 billion in 2020. Integrated into established financial infrastructures, the CME allows investors of all risk appetites to gain exposure.





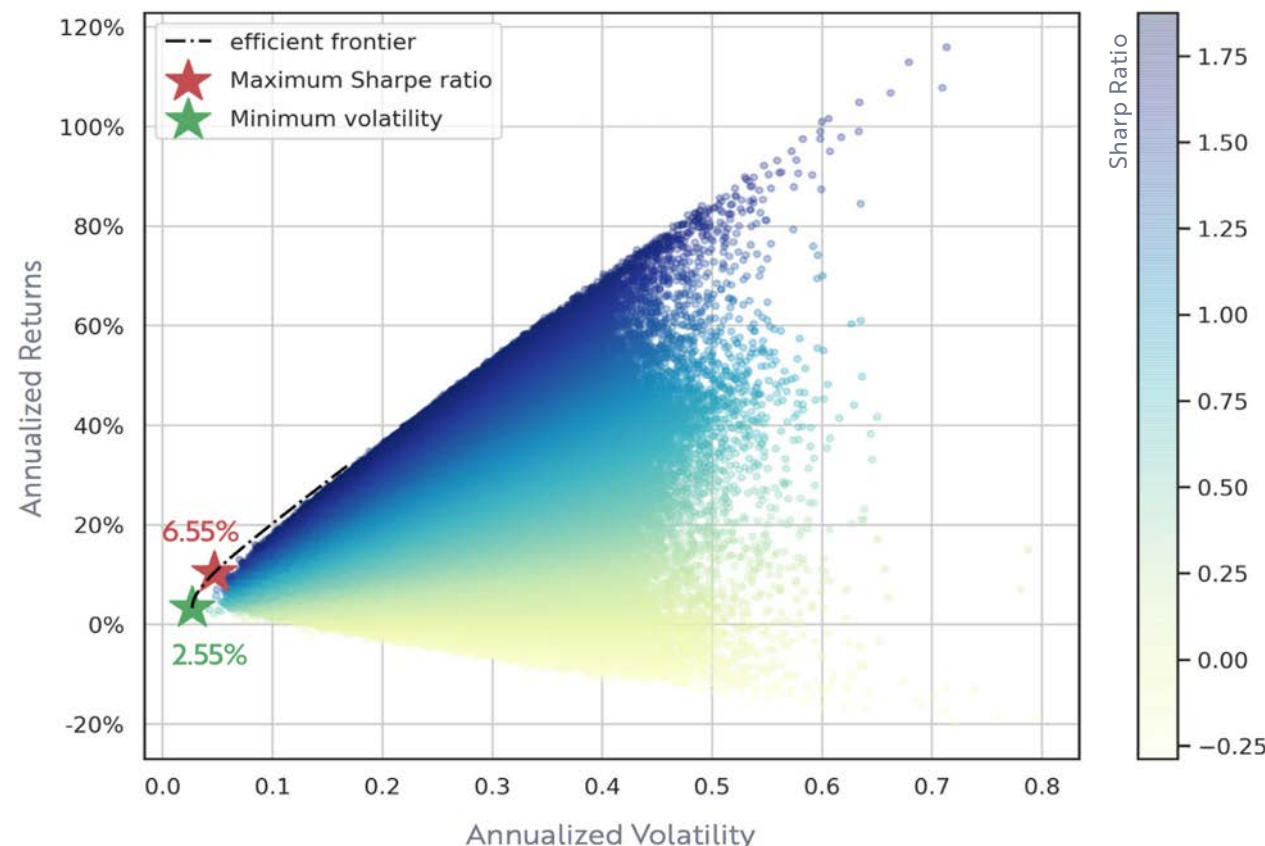
We Believe Bitcoin Has Earned An Allocation In Well-Diversified Portfolios

- Based on daily returns across asset classes during the past 10 years, our analysis suggests that allocations to bitcoin should range from 2.55% when minimizing volatility to 6.55% when maximizing returns.
- In ARK's analysis, we ran a Monte-Carlo simulation of 1,000,000 portfolios composed of various asset classes, as shown in the chart. The efficient frontier captures the highest returns possible for a given level of volatility. The stars indicate allocations associated with the maximum Sharpe Ratio and minimum volatility.

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Source: ARK Investment Management LLC, 2020 based on data sourced from: Coinmetrics.

Sharpe Ratio: The Sharpe ratio measures risk-adjusted returns. It is defined as the difference between an investment's returns and the risk-free return, divided by the standard deviation of the investment's returns. **Efficient Frontier:** The efficient frontier is the set of optimal investment portfolios that maximizes returns given defined levels of risk. **Simulation Methodology:** To model the potential bitcoin weights in a portfolio, we use a Monte Carlo simulation method. The basis of using this method is that the probability of varying outcomes is typically harder to determine given random variable interference. A Monte Carlo simulation mitigates this interference by focusing on repeating random samples to output a result. While typically more effective than relying on a single variable to forecast or estimate an outcome, our simulation assumes perfectly efficient markets and does not account for factors that are not built into the price movement, including macro trends and market sentiment. As a part of the simulation, we selected the following commonly used asset class benchmarks, analyzing their price behavior since 2011: Real Estate – The Morgan Stanley Capital International (MSCI), US Real Estate Investment Trust Index (RMZ), Commodities – The Crude Oil Futures (CL1 COMB), Currencies – MSCI Global Currency Index, Bonds – Bloomberg Barclays US Aggregate Bond Index, Equities – S&P 500, Gold – GLD

Simulated Portfolio Optimization Based On Daily Asset Class Returns



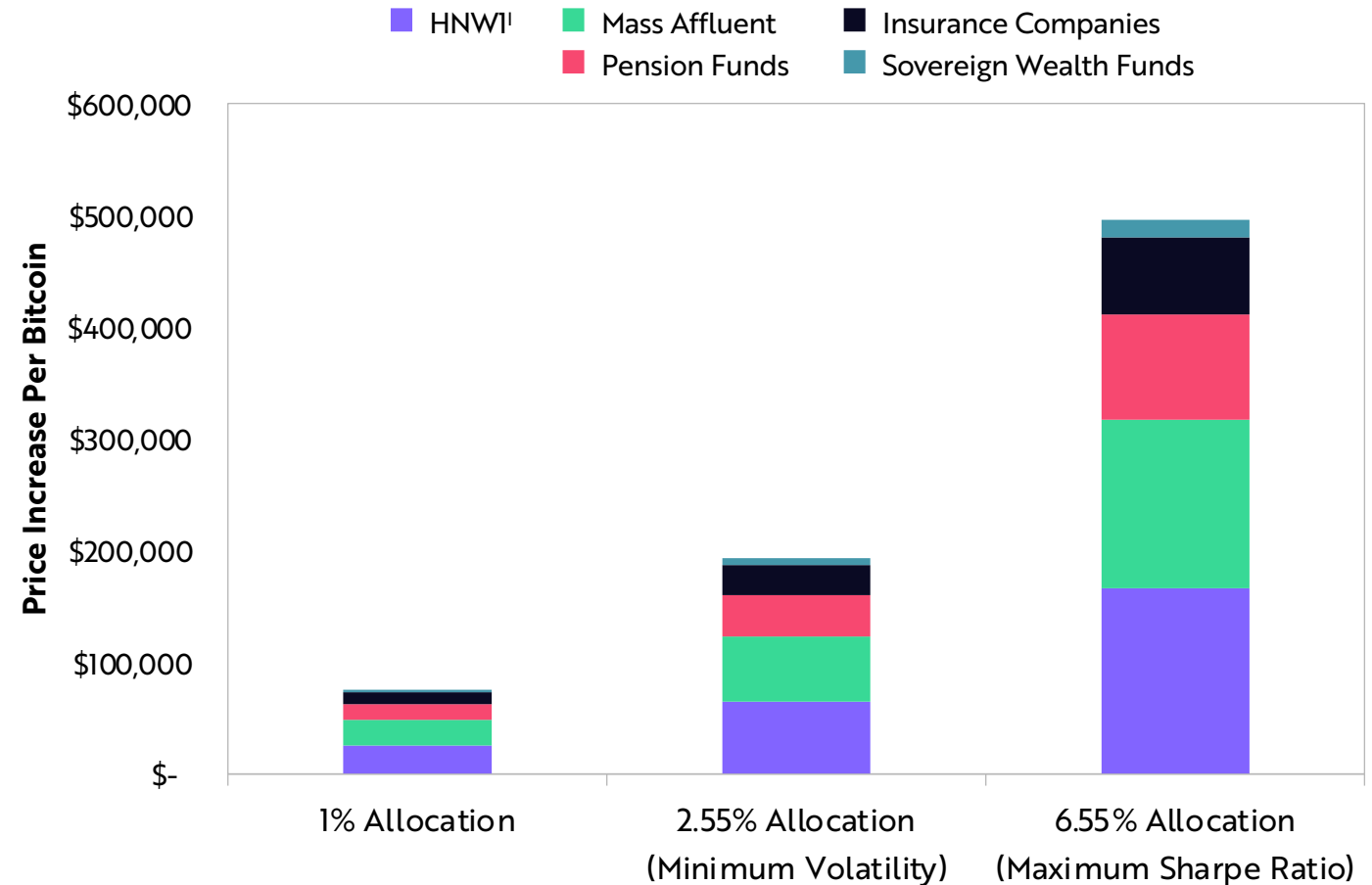


SIZING THE OPPORTUNITY

Institutional Investment Could Have A Substantial Impact On Bitcoin's Price.

- Based on ARK's simulated portfolio allocations, institutional allocations between 2.5% and 6.5% could impact bitcoin's price by \$200,000 to \$500,000.

Hypothetical Impact of Institutional Investment On The Price of Bitcoin



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[1] HNWI: High Net Worth Individuals. Source: ARK Investment Management LLC, 2020 based on data sourced from: PWC



Electric Vehicles (EVs)

EV Sales Should Accelerate Significantly

- Electric vehicles are approaching sticker price parity with gas-powered cars. Leaders in the EV market are developing innovative battery designs to enable longer range vehicles at lower costs.
- **Based on Wright's Law, ARK forecasts that EV sales should increase roughly 20-fold from ~2.2 million in 2020 to 40 million units in 2025.**
- We believe the biggest downside risk to our forecast is whether traditional automakers can transition successfully to electric and autonomous vehicles.

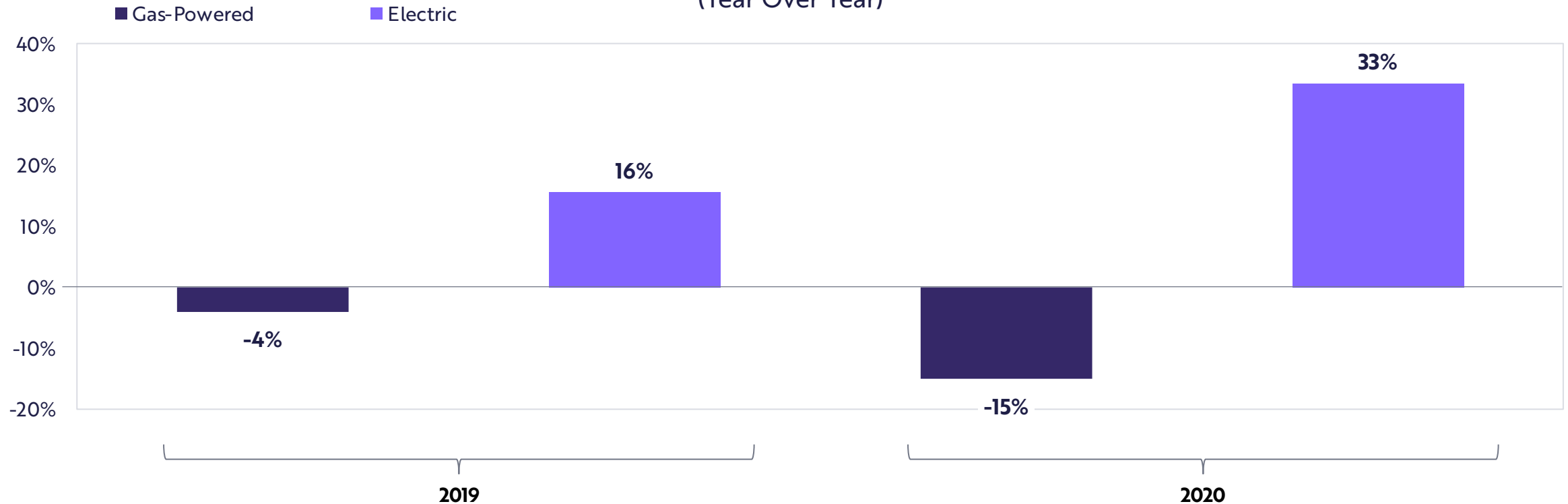
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Electric Vehicle Sales Have Taken Share In Good Times And Tough Times

While sales of gas-powered vehicles decreased during the recent COVID-19 pandemic, EV sales continued to increase globally.

Vehicle Sales Growth
(Year Over Year)

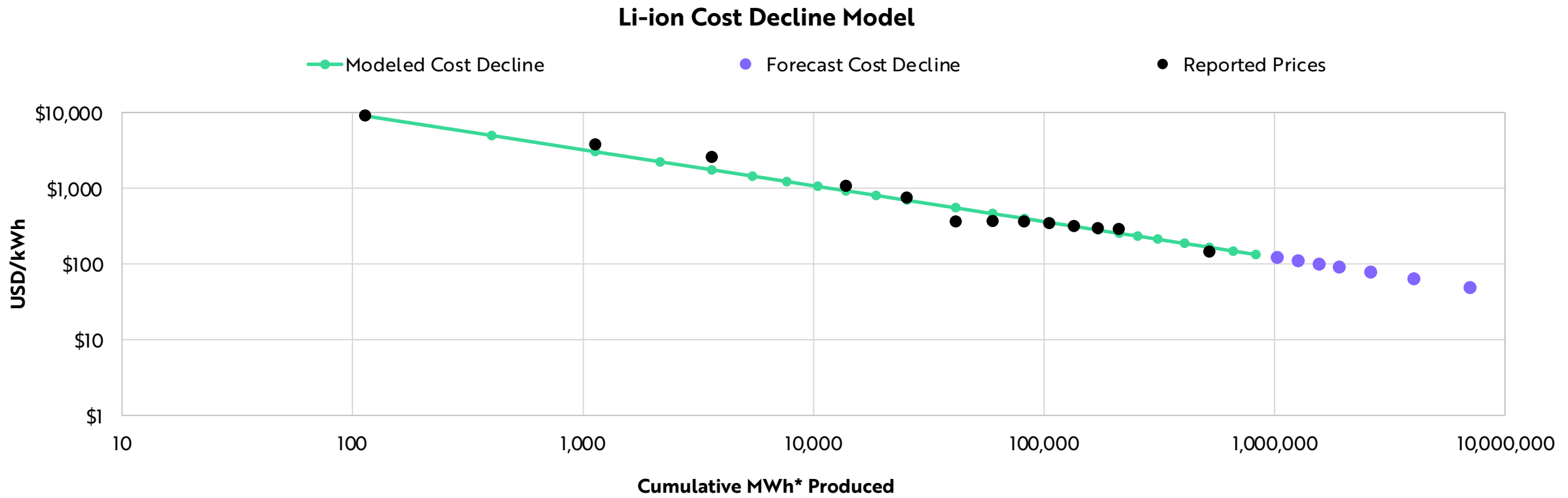


Source: ARK Investment Management LLC, 2020, based on data sourced from: "Global Auto Sales Forecasts: Hopes Pinned On China." Global Auto Sales Forecasts: Hopes Pinned On China, "Global Auto Sales Expected to Gain Momentum Next Year; 83.4 Million Light Vehicles to Be Sold In 2021, According to IHS Markit." Business Wire, 17 Dec. 2020, www.businesswire.com/news/home/20201217005798/en/Global-Auto-Sales-Expected-to-Gain-Momentum-Next-Year-83.4-Million-Light-Vehicles-to-Be-Sold-In-2021-According-to-IHS-Markit; Bekker, Henk. "2019 (Full Year) International: Worldwide Car Sales." Car Sales Statistics, 16 Jan. 2020, www.best-selling-cars.com/international/2019-full-year-international-worldwide-car-sales/.



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

According to Wright's Law, for every cumulative doubling of units produced, battery cell costs will fall by 28%. The largest cost component of an EV is its battery so these cost declines are critical to reaching price parity with gas-powered vehicles.



*A MWh is 1,000 kWh.

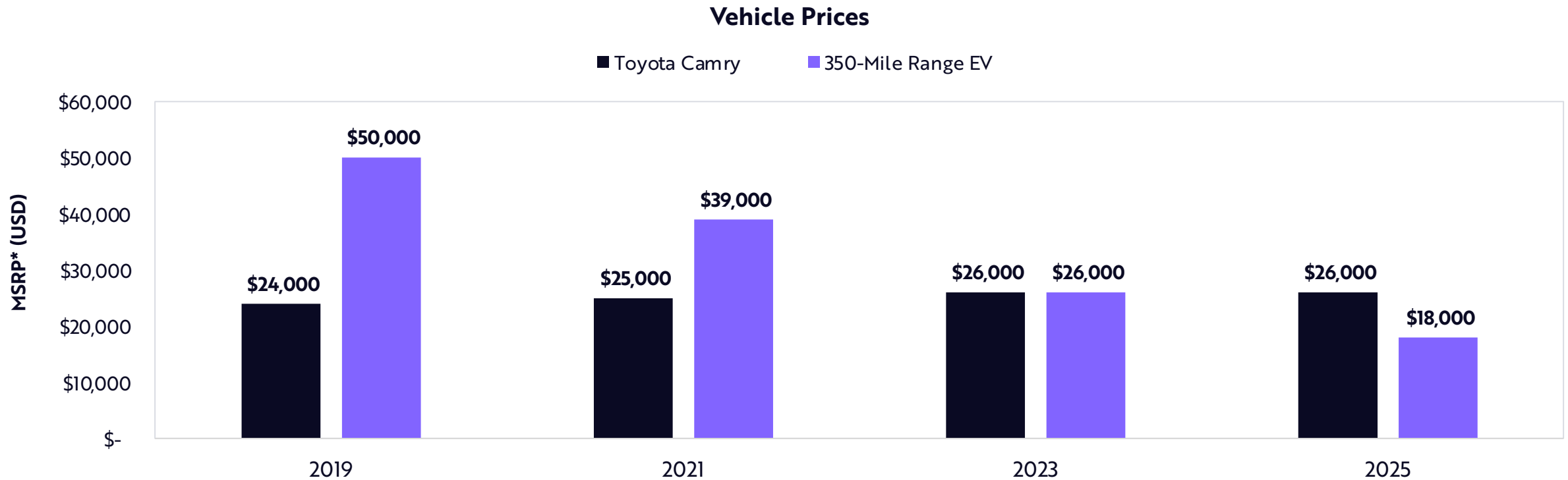
Forecasts are inherently limited and cannot be relied upon.

Source: ARK Investment Management LLC, 2020, based on data sourced from: Avicenne Energy, International Energy Agency (IEA), and Bloomberg New Energy Finance (BNEF).



Electric Vehicles Are Approaching Sticker Price Parity With Gas-Powered Cars

The total cost of ownership for a like-for-like EV dropped below that of a Toyota Camry in 2019.¹ Soon, sticker prices likely will do the same.



*MSRP stands for the Manufacturer Suggested Retail Price

[1] Total cost of ownership includes savings from gas, maintenance, insurance, and resale value.

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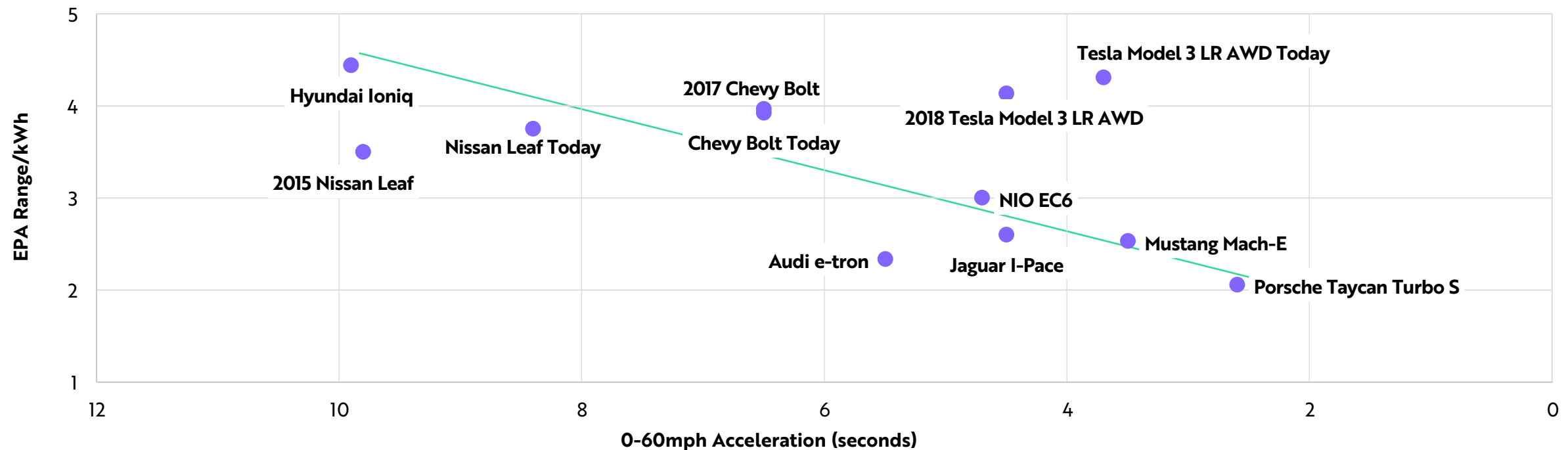
Source: ARK Investment Management LLC, 2020



In Addition To Cost, EVs Are Competing On Range And Performance

The auto market is undergoing a shift to both electric and autonomous. ARK believes that traditional automakers lack the software and electrical engineering talent necessary to succeed.

Electric Vehicle Efficiency vs. Performance



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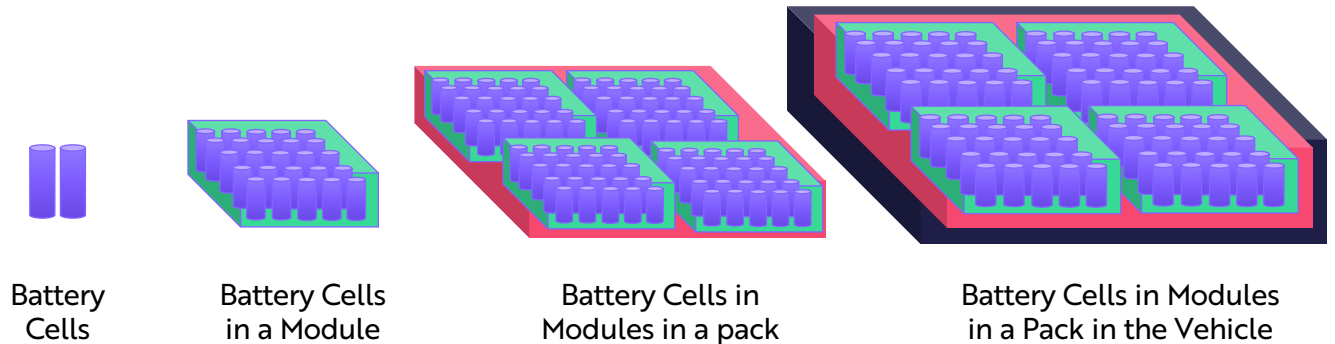
Source: ARK Investment Management LLC, 2020, based on data sourced from: Kierstein, Alex. "Polestar 2 Recalled Again, This Time for EV Component Issue." MotorTrend, MotorTrend, 3 Nov. 2020, www.motortrend.com/news/polestar-2-recall-inverter; O'Kane, Sean. "VW's First Mass-Market EV Suffers Delay Thanks to Software Struggles." The Verge, The Verge, 11 June 2020, www.theverge.com/2020/6/11/21288572/volkswagen-id3-ev-delay-software-vw-herbert-diess; "Hyundai to Expand Kona EV Recall to North America, Europe over Battery Fire Risk - Yonhap." Reuters, Thomson Reuters, 12 Oct. 2020, www.reuters.com/article/hyundai-motor-ev-battery/hyundai-to-expand-kona-ev-recall-to-north-america-europe-over-battery-fire-risk-yonhap-idUSKBN26X0GP.



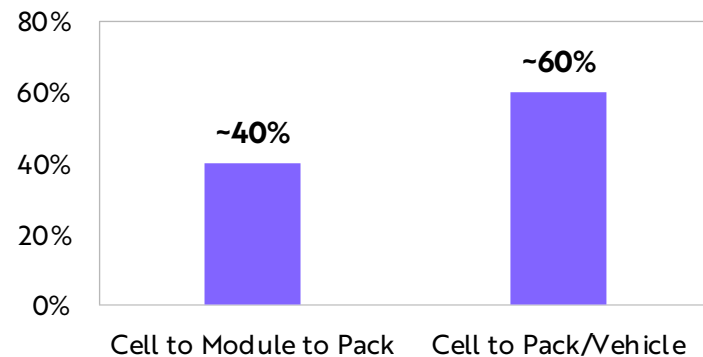
At Today's Battery Prices, Cell-To-Vehicle Technology Enables Longer Range EVs At Lower Prices

- Cell-to-vehicle designs increase the volumetric density of batteries by 50% relative to battery cells integrated into modules and packs.
- In the mass market segment, cell-to-vehicle technology should enable EV makers to lower energy density and cost cells, producing more kilowatt hours to increase the range of vehicles.
- At a given battery pack size, cell-to-vehicle technology should enable longer-range vehicles at lower price points.

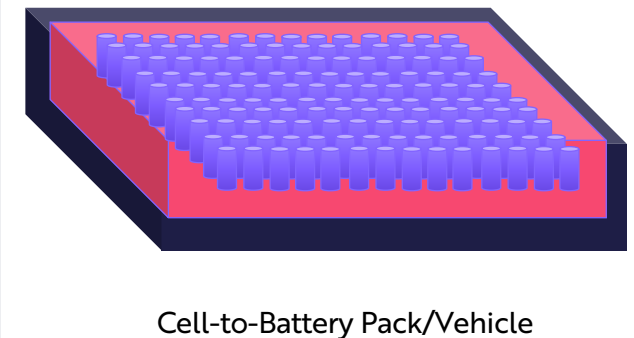
How most EVs are manufactured today:



Battery as Percent of Volumetric Density



How leaders in the space are manufacturing EVs:

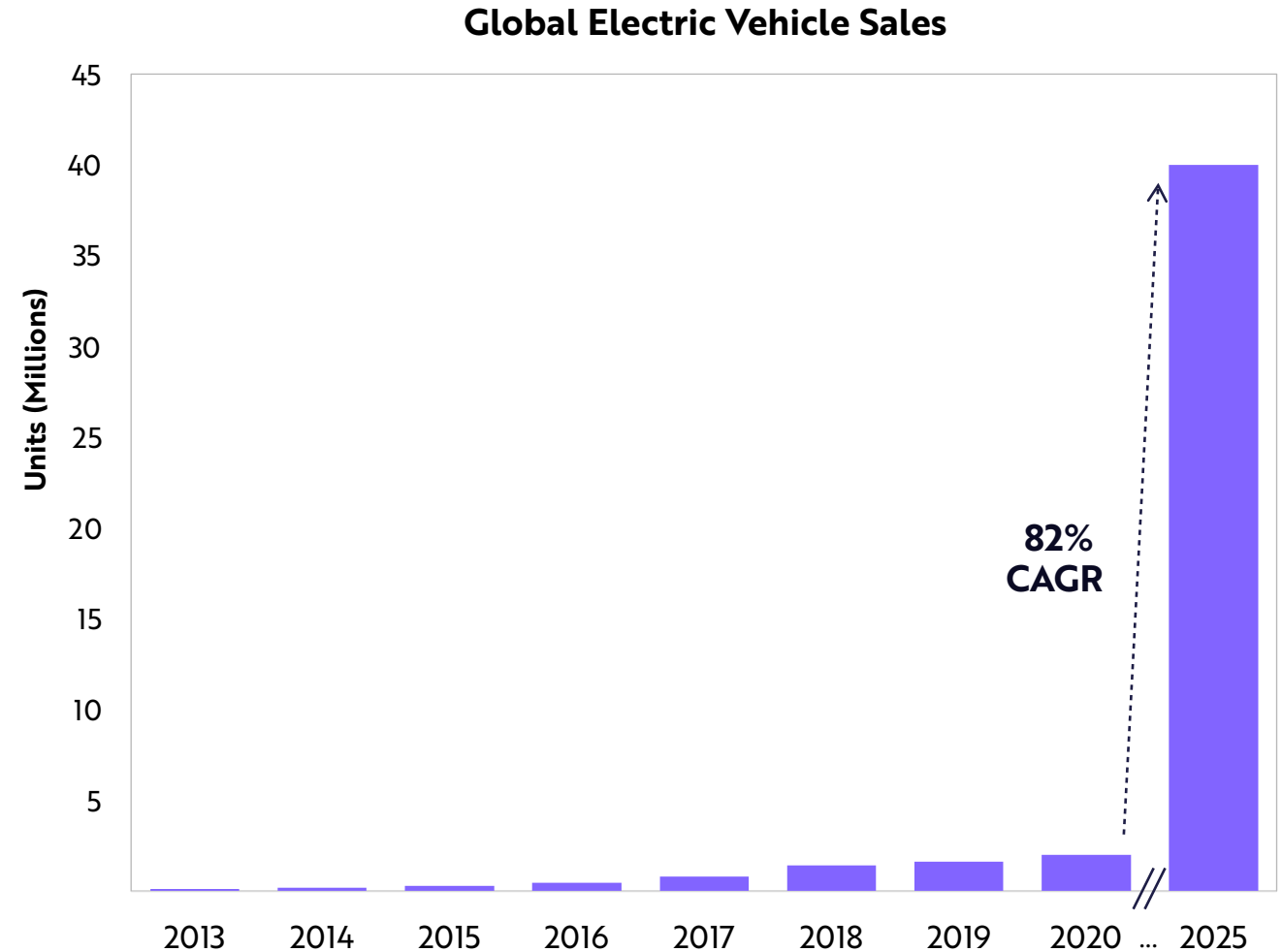




SIZING THE OPPORTUNITY

If Traditional Automakers Overcome Obstacles, Global EV Sales Could Scale Roughly 20-Fold From ~2.2 Million In 2020 To 40 Million By 2025.

- **ARK expects that sales of smaller, cheaper, “neighborhood electric vehicles” will rise dramatically as a share of total EV sales.**



Forecasts are inherently limited and cannot be relied upon.

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Source: ARK Investment Management LLC, 2020 based on data sourced from: EV-volumes.com



Automation

The Robots Are Coming...To Help You And Create Jobs

- Fears abound that automation will destroy jobs, but ARK believes it will empower humans, increasing both productivity and wage growth.
- Automation has the potential to shift unpaid labor to paid labor. For example, as food services automate, they will transform food prep, cleanup, and grocery shopping into market activities including food delivery.
- **ARK believes automation will add 5%, or \$1.2 trillion to US GDP during the next five years.**

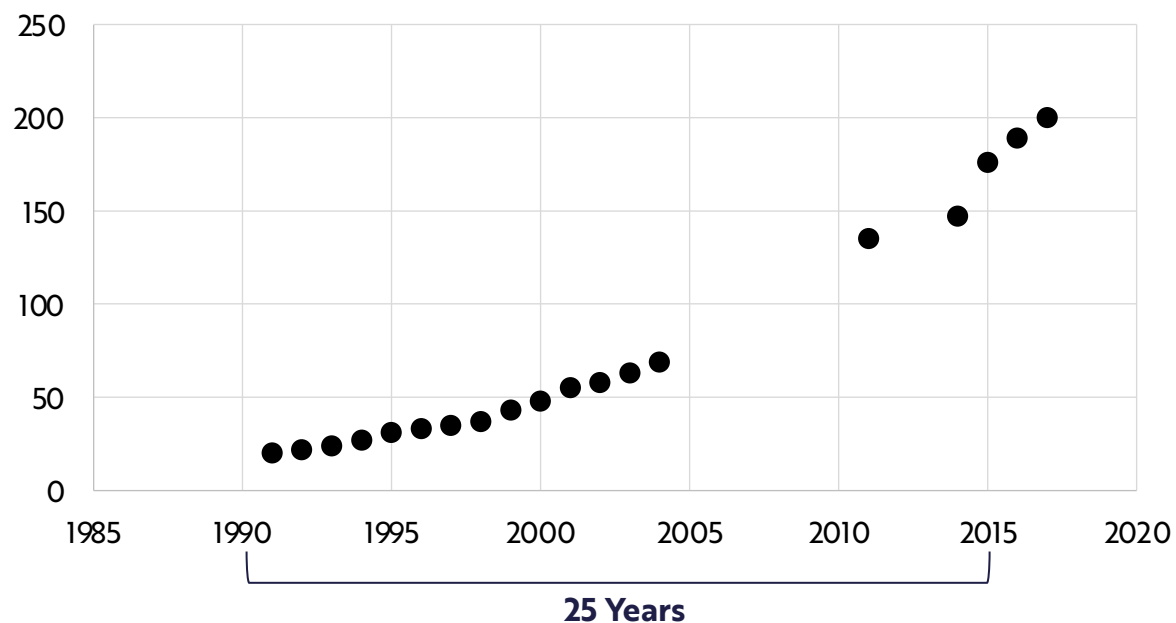
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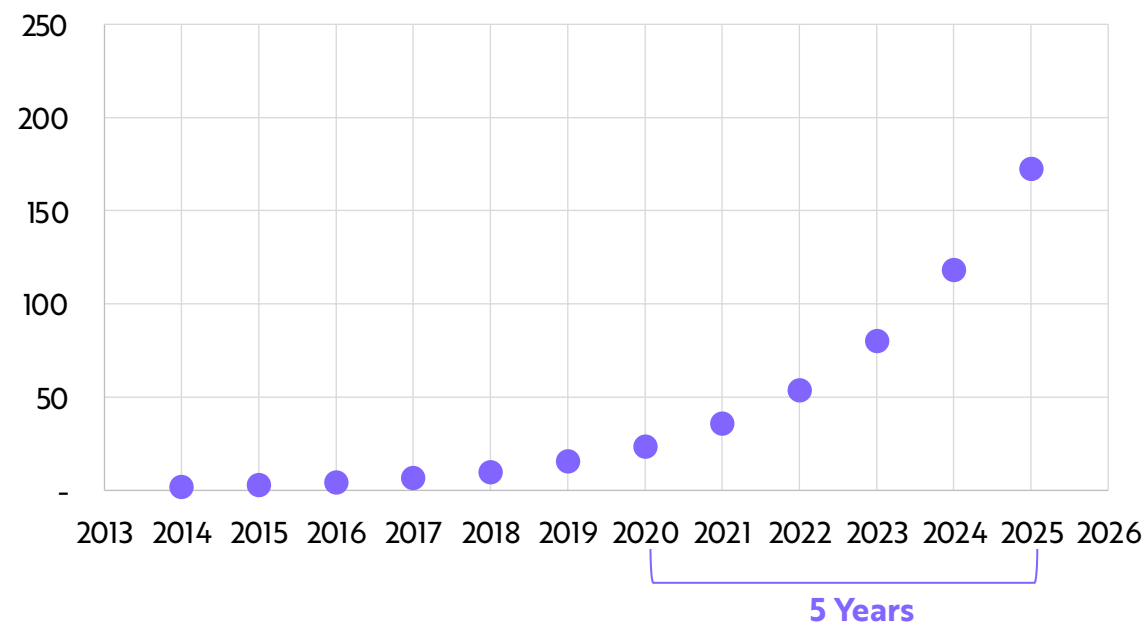
The US Economy Is At Automation Levels Similar To That Of US Manufacturing In The Early 1990s

While manufacturing took roughly 25 years to hit its current level of automation, ARK believes that the US economy will automate at a rate five times faster during the next five years.

US Manufacturing Robot Density
(Density per 10,000 Employees)



US Economy Automation Density
(Density per 10,000 Employees)



Forecasts are inherently limited and cannot be relied upon.

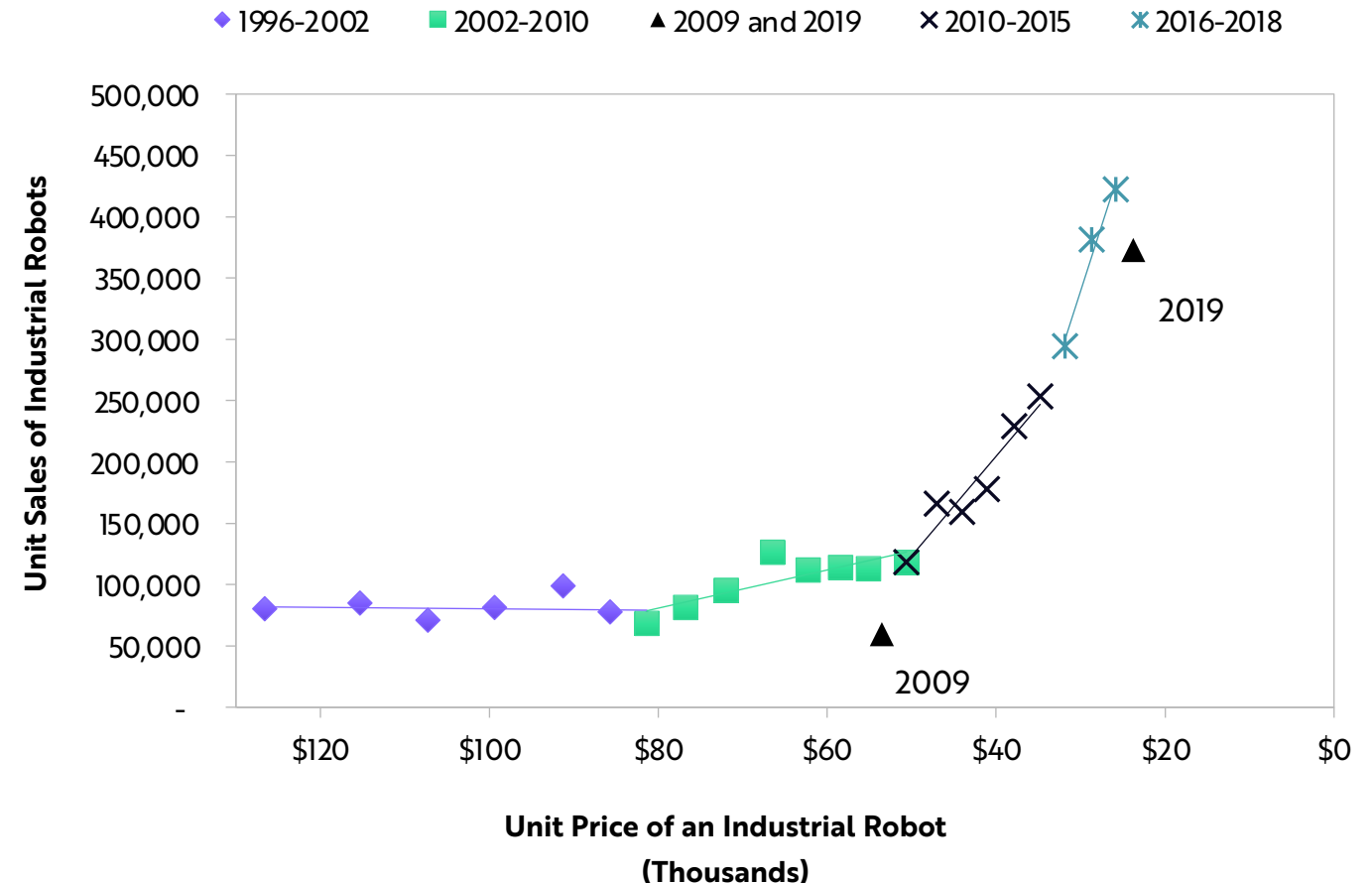
Source: ARK Investment Management LLC, 2020 based on data sourced from: Bureau of Labor Statistics (BLS), International Federation of Robotics (IFR), "The Future of Employment: How Susceptible Are Jobs to Computerization?" Oxford Martin School, <https://arkinv.st/2rFJJYW>.



Industrial Robot Demand Seems To Have Hit An Inflection Point

- Following the great recession in 2008/2009, perhaps in response to it, industrial robot demand hit an inflection point.
- Trade tensions between the US and China may have added to the momentum before COVID-19 created a headwind in 2020.
- According to ARK's research, short-term obstacles will not prevent a rebound in industrial robot sales and could encourage companies to automate and cut costs more aggressively.

Industrial Robot Price Elasticity of Demand

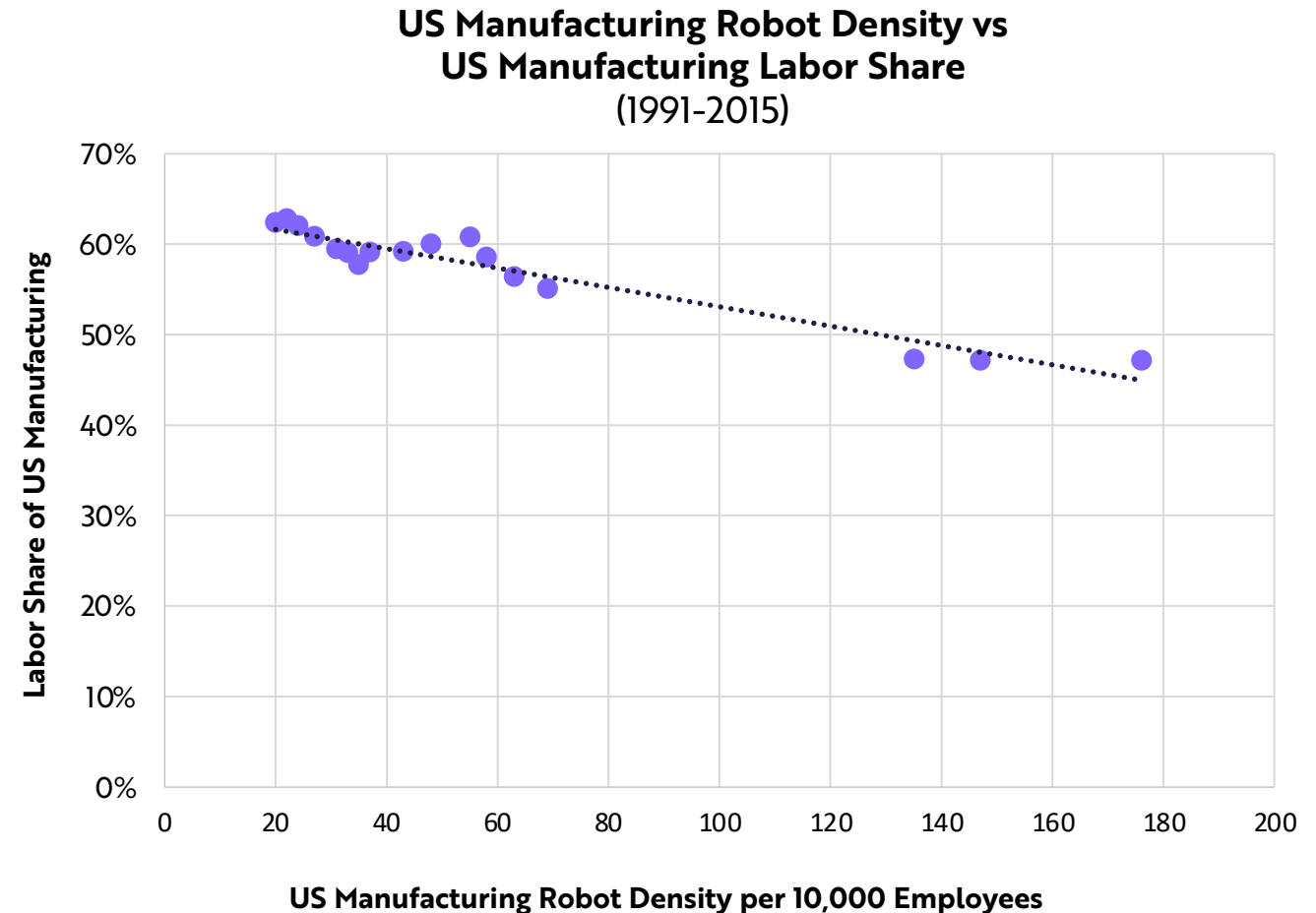




Increased Automation And Productivity Can Provide Many Economic Benefits

A drop in labor relative to capital does not suggest necessarily that wages are falling. Instead, output can grow faster than wages. Thanks to increased productivity and automation, ARK expects a combination of the following four outcomes:

- Higher wages: benefiting employees
- Lower prices: benefiting consumers
- Higher margins: benefiting companies
- Higher investments: creating virtuous cycles



Note: Each purple dot represents a year from 1991 – 2015.

*Labor share is employee wages as a percent of income.

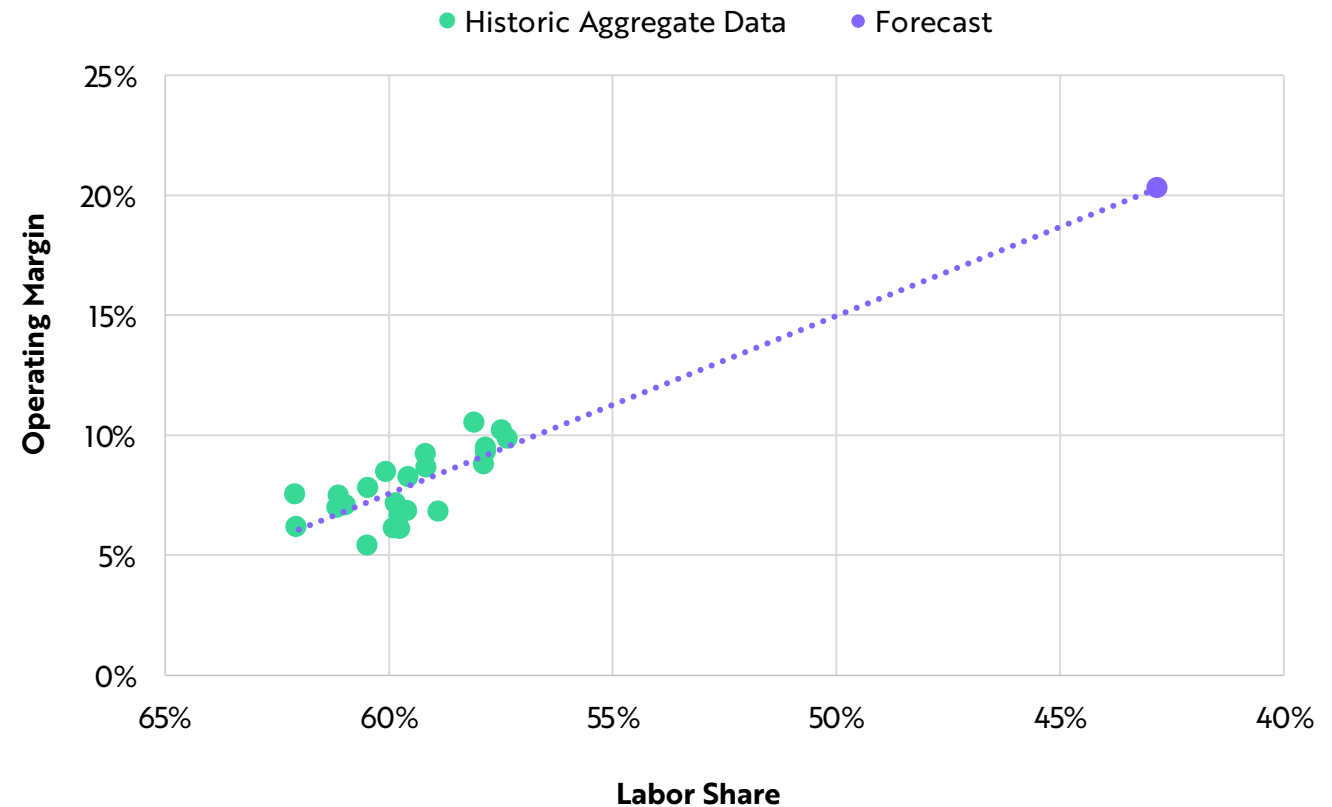
Source: ARK Investment Management LLC, 2020 based on data sourced from: Bureau of Labor Statistics (BLS), EU KLEMS Database September 2017 release, July 2018 revision.



Historically, When Labor Share Has Declined, Operating Margins Have Increased

- According to ARK's research, for every percentage drop in labor share in the industrial and agricultural sectors, operating margins increased 30 basis points and 280 basis points, respectively. We would not be surprised to see a similar relationship in all industries.
- If labor share were to fall 15%, in line with manufacturing, operating margins could double to more than 20%.

Labor Share: S&P Operating Profit Margins vs. All Industries Labor Share



Note: Chart time period is 1993-2015 the forecast is for 2025.

Labor share is employee wages as a percent of income.

Forecasts are inherently limited and cannot be relied upon.

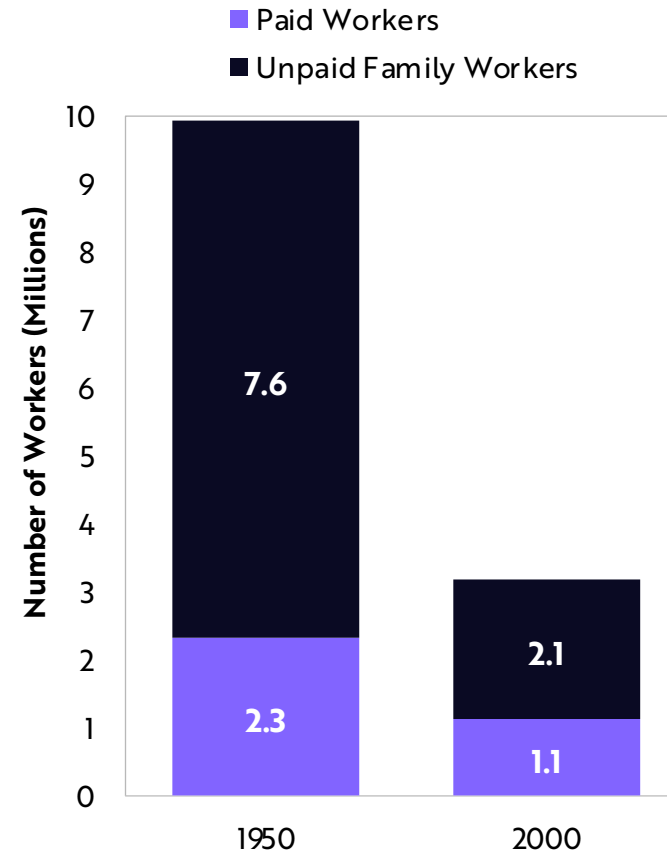
Source: ARK Investment Management LLC, 2020 based on data sourced from: EU KLEMS Database September 2017 release, July 2018 revision, Yardeni.



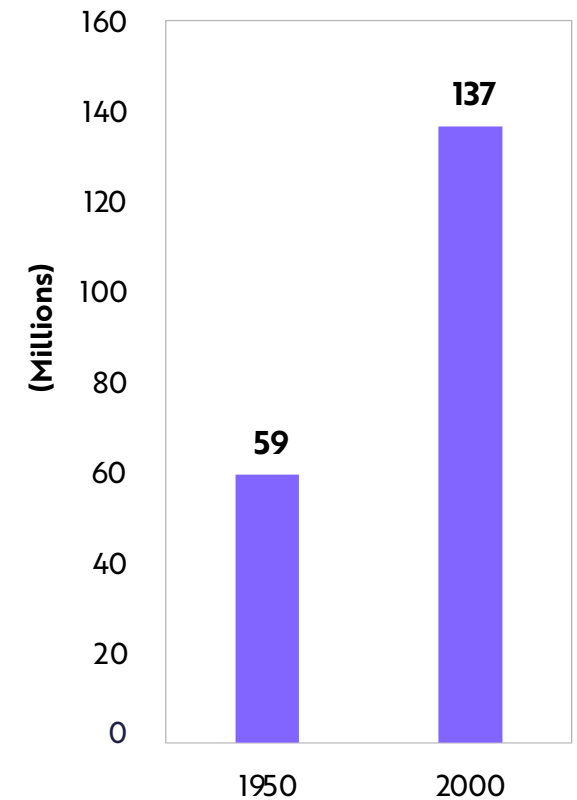
Automation Shifts “Unpaid” Labor Into “Paid” Labor

- 82% of the roughly 7 million people who lost jobs in agriculture between 1950 and 2000 were unpaid family workers.¹
- The loss of jobs in one industry, even a major industry, does not suggest that total employment will decline.
- The washing machine monetized unpaid time spent cleaning clothes as washing machine manufacturers and laundromats took hold.
- As food services automate, they will continue to transform food prep, cleanup, and grocery shopping into market activities including food delivery.
- Automated products and services are less expensive than their alternatives.

Paid vs Unpaid Farm Workers



Employed Persons in the US



[1] Unpaid family workers include unpaid family members and self-employed famers.

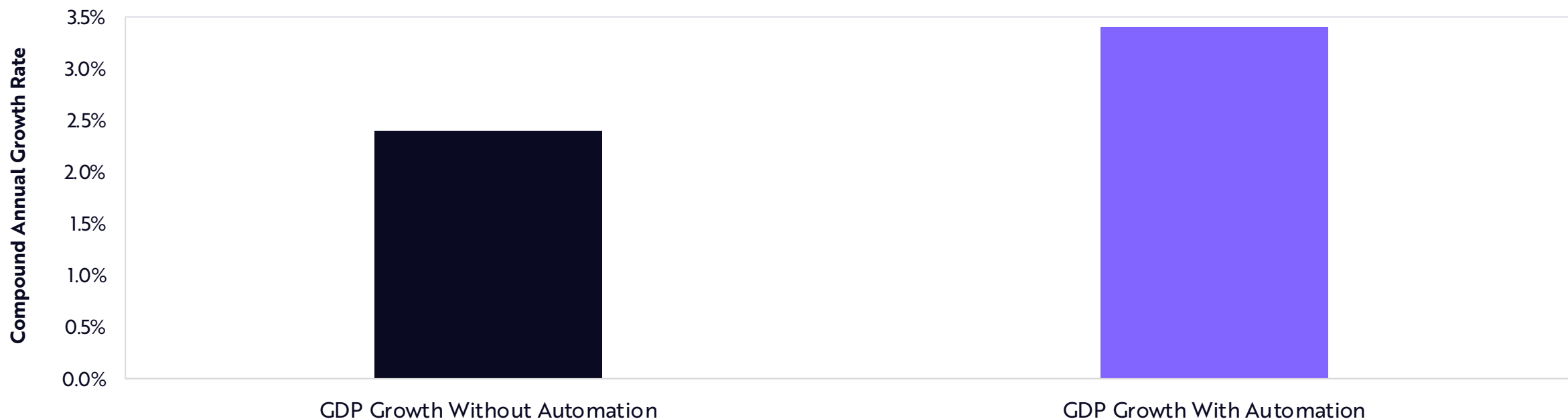
Source: ARK Investment Management LLC, 2020 based on data sourced from: Economic Research Service United States Department of Agriculture <https://www.ers.usda.gov/topics/farm-economy/farm-labor/#size>.



SIZING THE OPPORTUNITY

Automation could add 5%, or \$1.2 trillion, to US GDP during the next five years. ARK believes automation will boost US real GDP growth by 100 basis points on average per year to 3.4%.

Real US GDP Growth (2020-2025)



Forecasts are inherently limited and cannot be relied upon.

Source: ARK Investment Management LLC, 2020 based on data sourced from: "The Future of Employment: How Susceptible Are Jobs to Computerization?" Oxford Martin School, <https://arkinv.st/2rFJJYW>, Bureau of Labor Statistics (BLS), International Monetary Fund (IMF) World Economic Outlook.



Autonomous Ride-Hailing

Autonomous Ride-Hailing Is Likely To Dominate Urban Transport

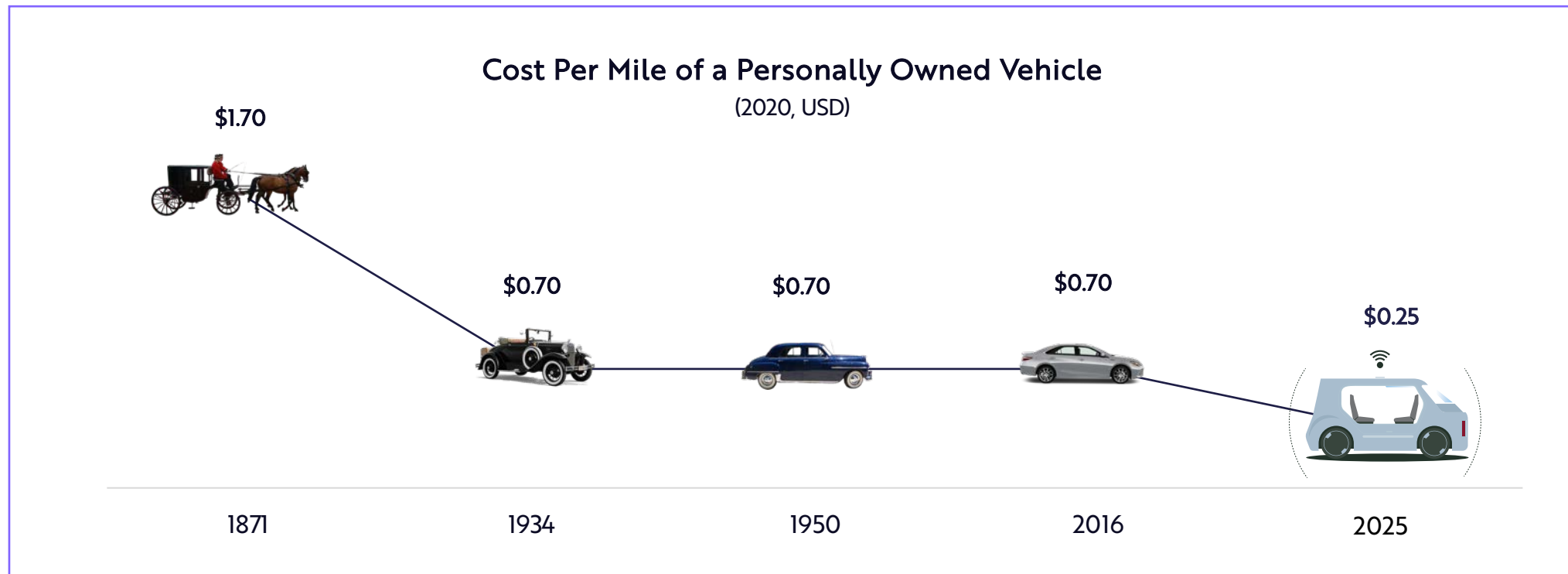
- We believe autonomous ride-hailing will reduce the cost of mobility to one tenth the average cost of a taxi today, spurring widespread adoption.
- **ARK's research suggests that autonomous ride-hailing platforms will generate more than \$1 trillion in profits per year by 2030. In addition, automakers and fleet owners could enjoy profits of \$250 billion and \$70 billion, respectively.**

09



Autonomous Ride-Hailing Is Likely To Be Affordable

Adjusted for inflation, the cost to own and operate a personal car has not changed since the Model T rolled off the first assembly line. ARK estimates that, at scale, autonomous taxis will cost consumers \$0.25 per mile, spurring widespread adoption.



Forecasts are inherently limited and cannot be relied upon.

Note: ARK had estimated previously that an autonomous taxi could price at \$0.35 per mile. We have refined our estimates and believe that autonomous taxis could be even cheaper, at only \$0.25 per mile.

Source: ARK Investment Management LLC, 2020; Morton Salt Company Records, American Automobile Association (AAA).

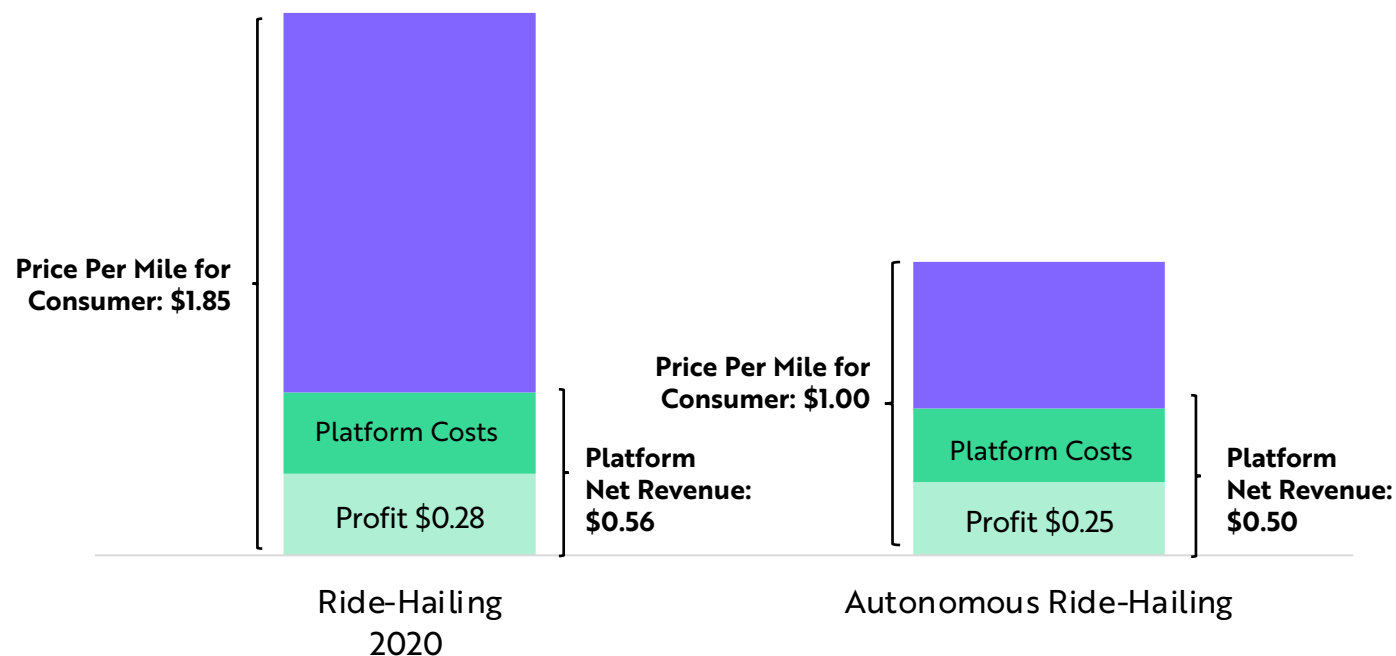


Robotaxis Should Expand The Ride-Hailing Market

- According to ARK's research, the ride-hailing market today generates roughly \$150 billion in revenues globally with take rates of 10-30% and profit margins as high as 50% in high performing cities.
- Likewise, autonomous ride-hailing could generate 50% margins, but its lower price point should expand the total market from \$150 billion in revenues with take rates up to 60%, to \$6-7 trillion by 2030.

Economics of Ride-Hailing vs. Autonomous Ride-Hailing

Assuming 3 Million Vehicles on Network



Note: Price for autonomous ride-hailing shown above would be in the early years of commercialization. ARK expects prices to drop as low as \$0.25 per mile as the market scales.

Forecasts are inherently limited and cannot be relied upon.

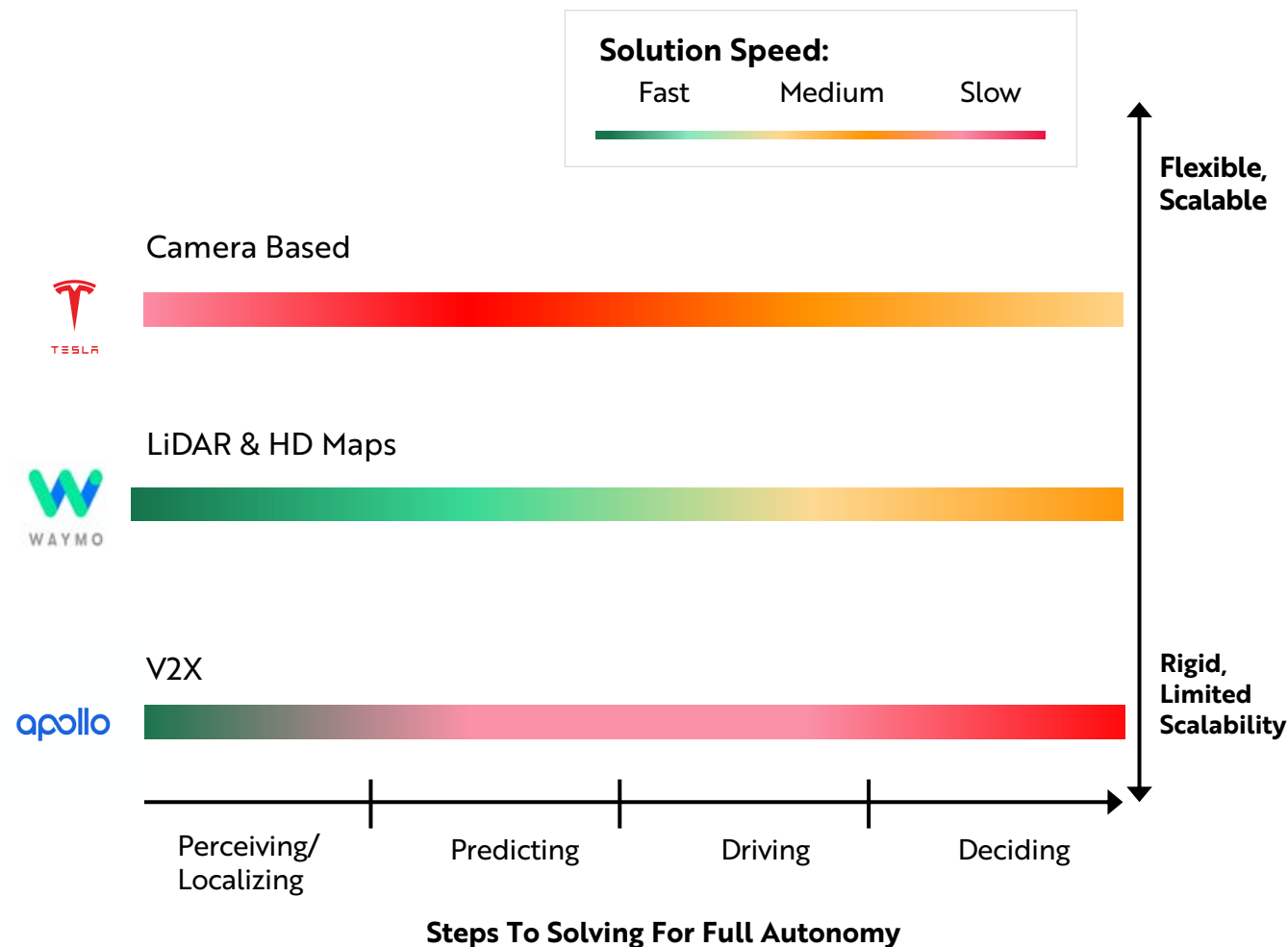
For informational purposes only and should not be considered investment advice, or a recommendation to buy, sell or hold any particular security.

Source: ARK Investment Management LLC, 2020 based on ARK estimates and available financials for Uber, Lyft, and Didi.



Three Autonomous Strategies Are Evolving

- **Tesla's** approach is camera-based. With less accurate sensors than LiDAR, making the path to full autonomy a more difficult problem to solve, cameras do not rely on HD maps and should enable a much more scalable service. Tesla's could be the first autonomous taxi network to scale nationally.
- **Alphabet's Waymo** is using LiDAR and HD mapping. Waymo launched its autonomous network in Arizona but probably will need time and significant resources to scale nationally.
- Many Chinese players, including **Baidu's Apollo**, are building out infrastructure sensors to help vehicles identify road signs and traffic. Requiring large infrastructure investments, this approach to autonomous ride-hailing seems to be the most rigid and least scalable of the three.



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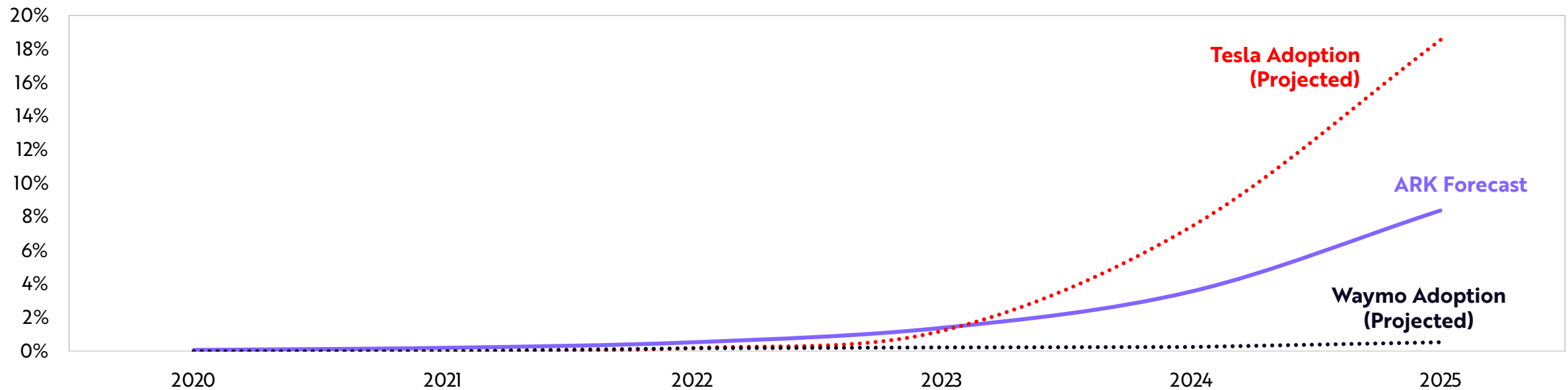
Source: ARK Investment Management LLC, 2020 based on data sourced from: Tesla, Alphabet, and Baidu



Scalability Will Determine The Pace Of Autonomous Ride-Hailing Adoption

If Tesla launches its autonomous ride-hailing service successfully in 2022, ARK estimates adoption could approach 20% by 2025. If Waymo or GM is successful, adoption probably will be limited to 1% during the next five years.

**North America Autonomous Vehicle Adoption
As a Percent of Urban Miles Traveled**



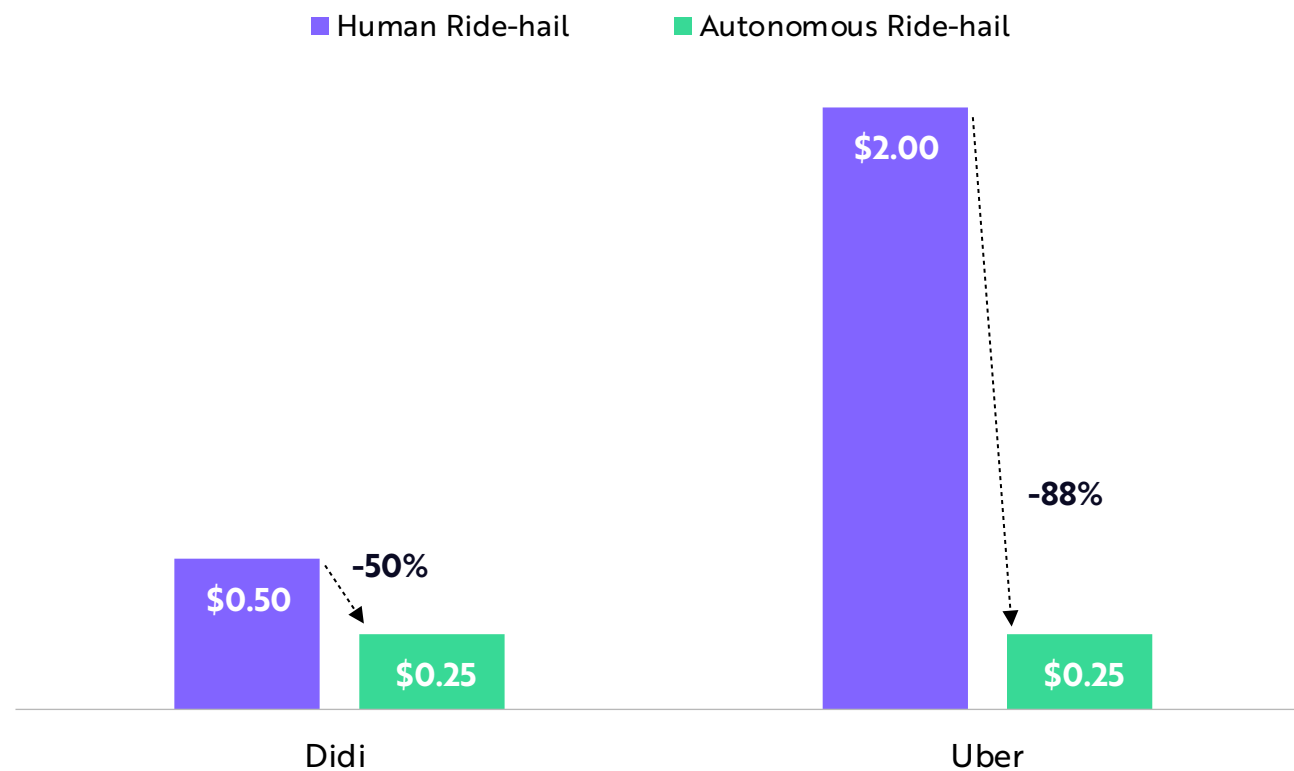
Note: ARK assigns a 30% probability that Tesla will launch autonomous ride-hailing successfully



Demand Response Could Be Higher In Developed vs. Developing Countries

- We believe autonomous ride-hailing will undercut the cost of human-driven ride-hailing by roughly 90% in the US and 50% in China.
- As a result, the demand response to inexpensive autonomous travel could be higher in developed countries than in developing countries.
- Platform providers, or companies that own the autonomous technology stack, should garner the lion's share of autonomous ride-hailing profits.

Human Ride-Hailing vs. Autonomous Ride-Hailing Average Price Per-Mile in China vs. The US



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, 2020 based on data sourced from: "Didi Chuxing Still a Ride-Hailing Giant despite 2018 Safety Setbacks." South China Morning Post, 22 Jan. 2019, www.scmp.com/tech/start-ups/article/2181542/didi-numbers-ride-hailing-firm-covered-more-miles-2018-5-earth, Feng, Linyan. "Beyond DiDi's Safety Report: DiDi Posts 21 Million Rides Per Day in Q1." EqualOcean, EqualOcean, 2 July 2019, equalocean.com/auto/20190703-didi-posts-21-million-rides-per-day-in-q1, Helling, Brett, et al. "How Much Does Uber Cost? – A Comprehensive Guide." Ridester.com, 14 Aug. 2020, www.ridester.com/uber-rates-cost/.



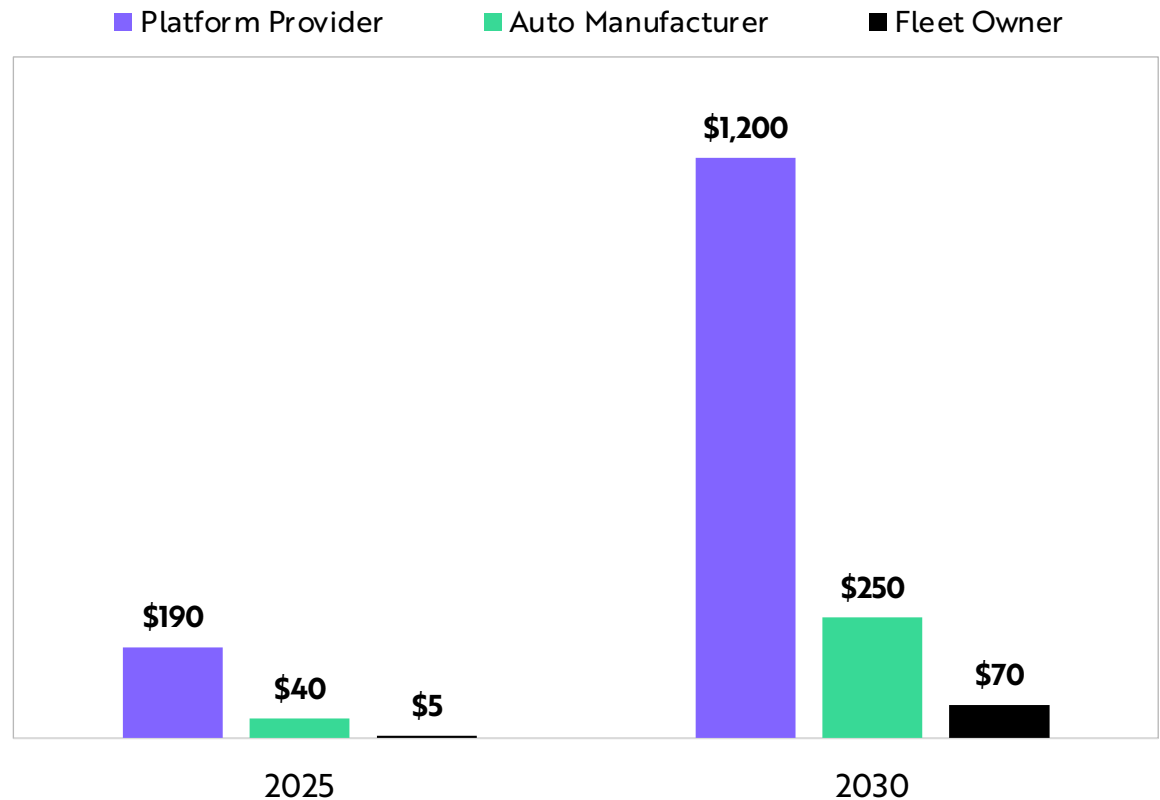
SIZING THE OPPORTUNITY

ARK Believes That Autonomous Ride-Hailing Platforms Could Generate More Than \$1 Trillion In Operating Earnings Annually by 2030.

- Auto manufacturers with successful electric vehicle platforms, partnered with autonomous technology providers, could generate roughly \$250 billion in earnings annually by 2030.
- Fleet owners that own, house, and maintain autonomous ride-hailing vehicles could generate roughly \$70 billion in earnings annually by 2030.
- **Enterprise value for autonomous platform operators could scale to 3.8T by 2025.**

Estimated Operating Earnings Across The Autonomous Value Chain

(Billions, USD)

*Note: Values are rounded.*



10

Drone Delivery

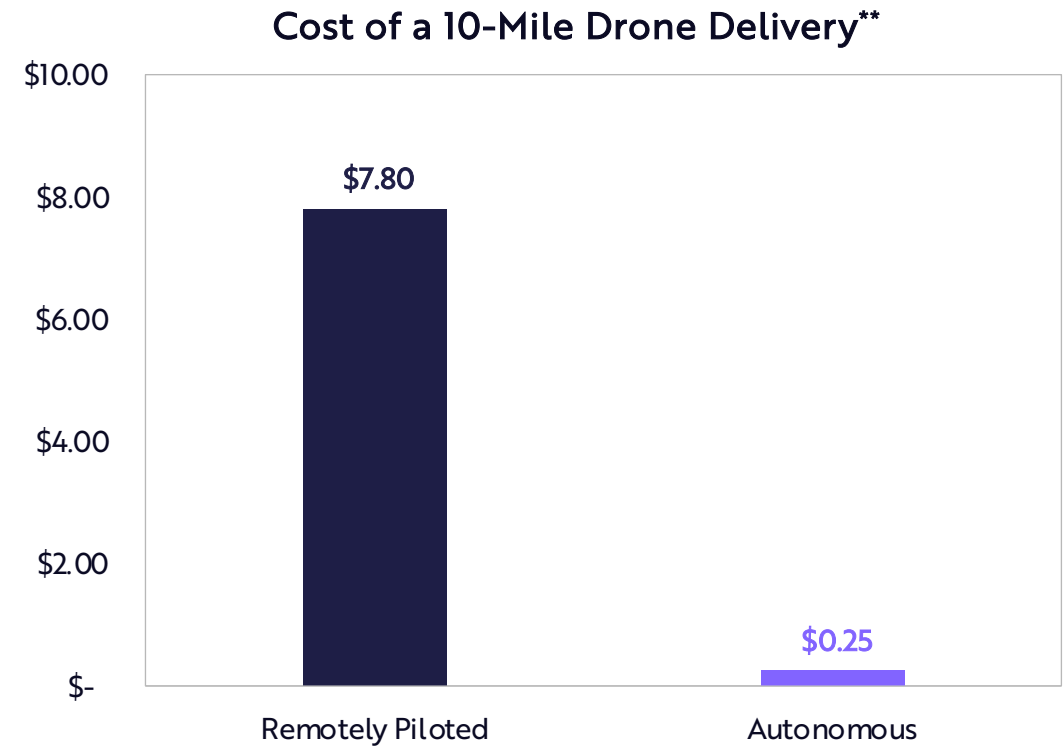
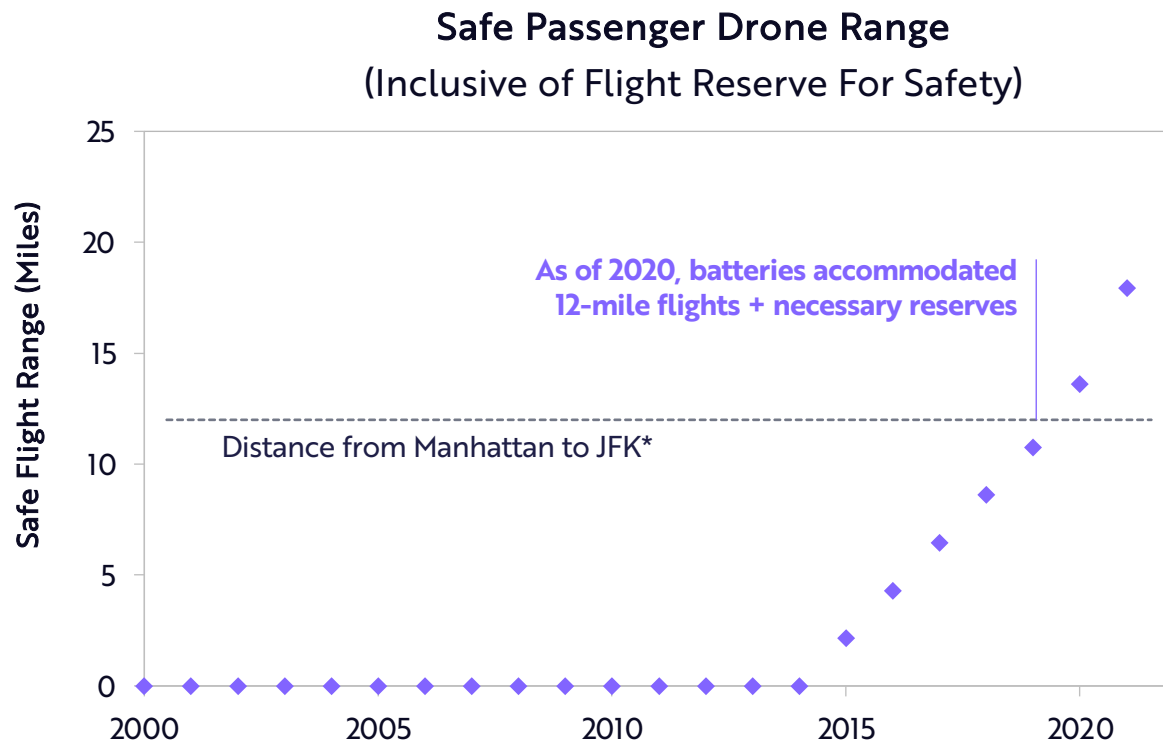
Drones Should Reduce The Cost To Transport Goods And People Dramatically

- Lower battery costs and autonomous technology should power aerial drones.
- ARK believes that in the not-too-distant future drones will deliver our packages, food, and even people quicker and more conveniently than ever before. Drones are likely to transform shopping behavior, reduce travel time, and save lives.
- **ARK believes that drone delivery platforms will generate roughly \$275 billion in delivery revenues, \$50 billion in hardware sales, and \$12 billion in mapping revenue by 2030.**



Autonomous Air Travel Has Become Possible And Affordable

Battery technology is improving, enough so that flight energy reserves can meet regulations, enabling air taxis and air ambulances to take to the skies safely. In addition, machine learning improvements have enabled autonomous flight, reducing costs dramatically.



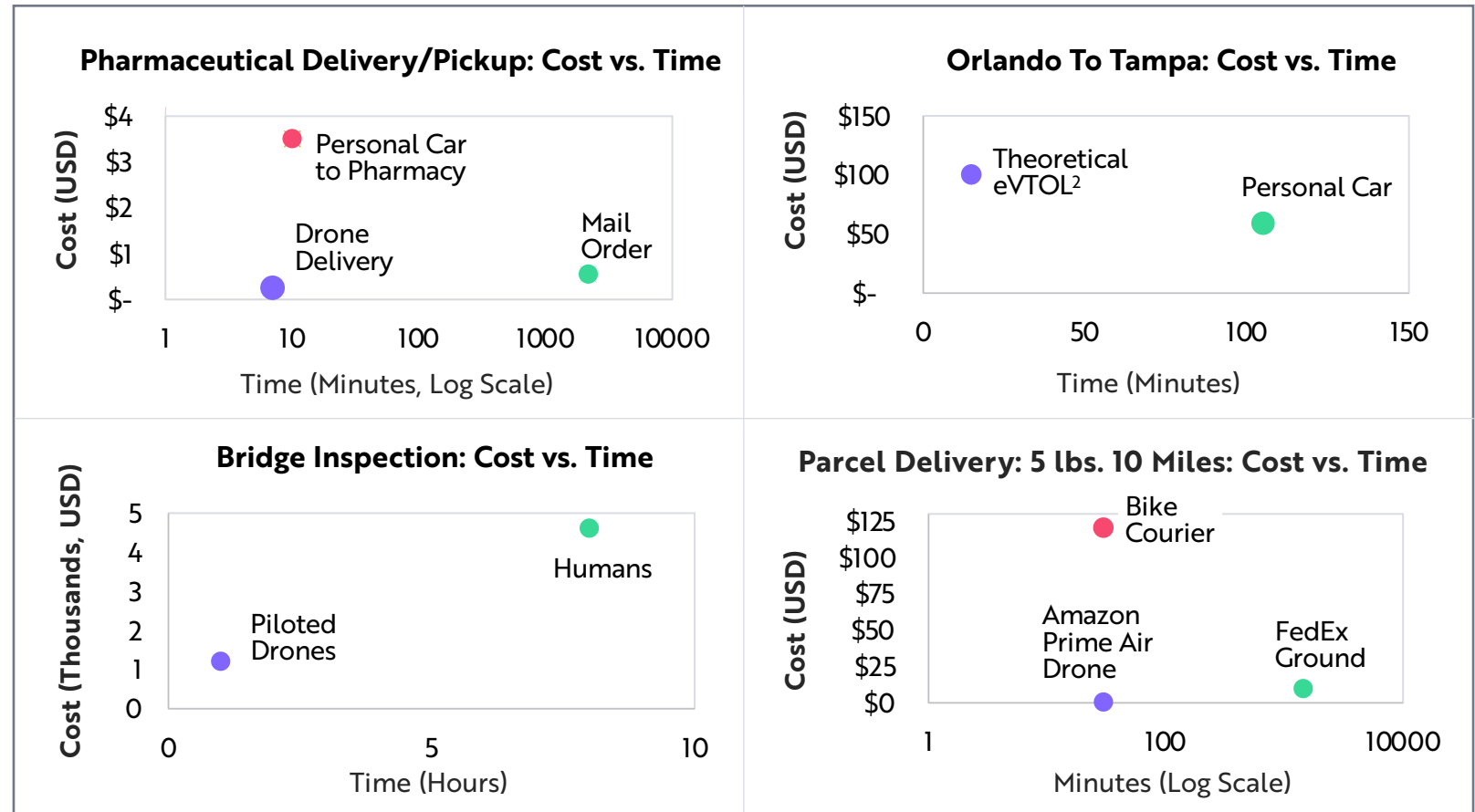
*JFK – John F. Kennedy International Airport. **Note: Prices shown for drone technology are in the future when each technology reaches scale. While ARK estimates drone delivery services will commercialize in the next 5-10 years, exact dates will be dependent on regulatory approval. Forecasts are inherently limited and cannot be relied upon. | Source: ARK Investment Management LLC, 2020 based on data sourced from “Menu.” FAR/AIM: PART 91-GENERAL OPERATING AND FLIGHT RULES, [www.gleim.com/aviation/faraim/index.php?fullTextNum=91&terms%5B%5D=\\$FAR](http://www.gleim.com/aviation/faraim/index.php?fullTextNum=91&terms%5B%5D=$FAR).



Drones Enable Cost Savings And Convenience

- In the past two years, the Federal Aviation Authority (FAA) has kickstarted the commercial drone industry by allowing companies to operate drones beyond line of sight and, in some cases, to operate drone airlines.
- Florida is building the first US passenger drone vertiport,¹ with plans to operate in 2025.

Drone Delivery Costs At Scale Relative to Competitor Costs Today



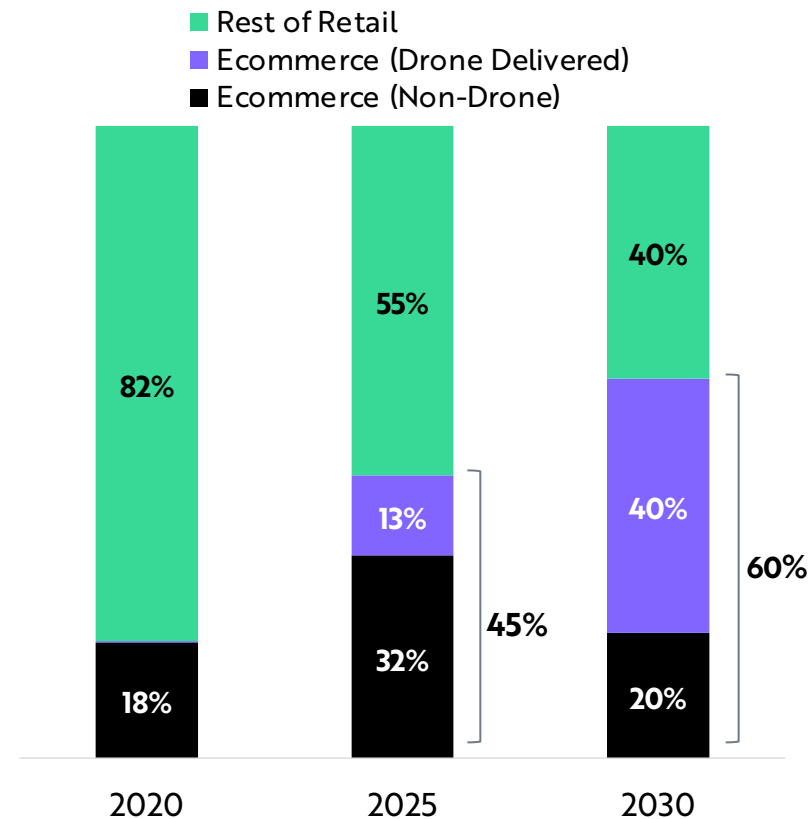
[1] Vertiport is an airport for aircrafts which take off and land vertically. [2] eVTOL: electric vertical takeoff and landing. Forecasts are inherently limited and cannot be relied upon. For informational purposes only and should not be considered investment advice, or a recommendation to buy, sell or hold any particular security. Source: ARK Investment Management LLC, 2020 based on data sourced from Are you Ready for Take Off? - Presentation by Remo Gerber, CCO of Lilium at the NOAH Conference London 2017, Old Billingsgate on the 3rd of November 2017, Kelling SE. Exploring Accessibility of Community Pharmacy Services. *Inov Pharm.* 2015;6(3):Article 201. <http://pubs.lib.umn.edu/innovations/vol6/iss3/6>, Carey, Liz. "North Carolina DOT Approved to Inspect Bridges with Drones." *Transportation Today*, 6 Oct. 2020, transportationtodaynews.com/featured/19901-north-carolina-dot-approved-to-inspect-bridges-with-drones/. "FedEx Ground® Shipping." FedEx, www.fedex.com/en-us/shipping/ground.html. "Mail & Shipping Services." USPS, www.usps.com/ship/mail-shipping-services.htm. Report • By Elise Gould • February 20. "State of Working America Wages 2019: A Story of Slow, Uneven, and Unequal Wage Growth over the Last 40 Years." Economic Policy Institute, www.epi.org/publication/swa-wages-2019/.



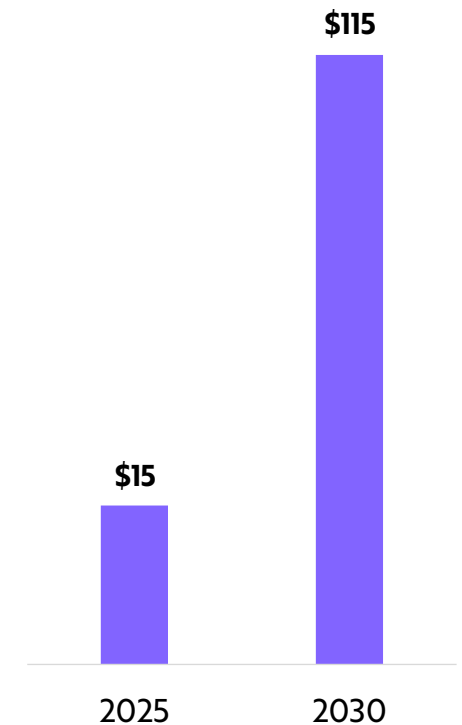
Drones Could Deliver A Substantial Share Of E-Commerce Shipments By 2030

- COVID-19 accelerated e-commerce experimentation and adoption with contactless drone deliveries.
- ARK estimates that at some point during the next five years, drones will deliver more than 20% of parcel shipments.

Global E-Commerce Share of Retail With Drones



Global Parcel Drone Delivery Revenue (Billions, USD)



Forecasts are inherently limited and cannot be relied upon.

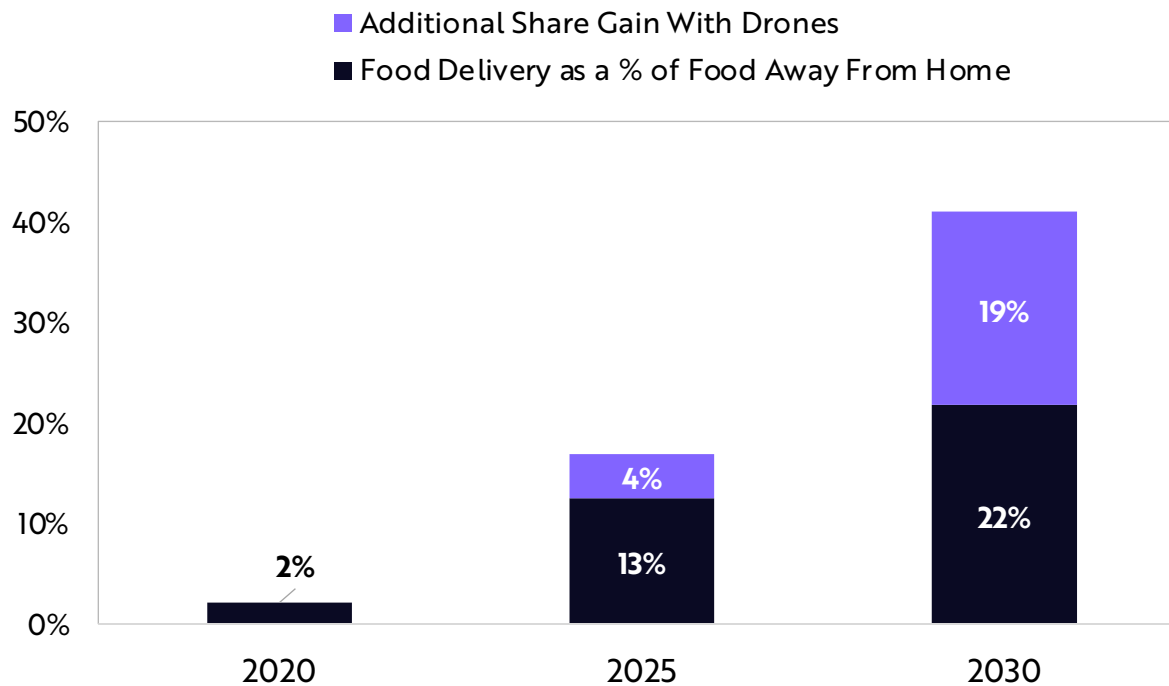
Source: ARK Investment Management LLC, 2020 based on data sourced from "Pitney Bowes Parcel Shipping Index Reports Global Parcel Shipping Reaches \$279 Billion in Revenue." Pitney Bowes, 28 Aug. 2018, <https://arkinv.st/2QjSeSQ>; "Data and Research on Digital for Business Professionals." EMarketer, EMarketer, <https://arkinv.st/2trGQeE>; Total Retail Sales of Consumer Goods in December 2017, National Bureau of Statistics of China, 25 Jan. 2018, <https://arkinv.st/36mBKz6>; "Monthly Sales for Retail and Food Services by Kind of Business: Retail Sales by Kind of Business, Millions of Dollars, Seasonally Adjusted." FRED, Federal Reserve Bank of St. Louis, <https://arkinv.st/2ZJWSN4>.



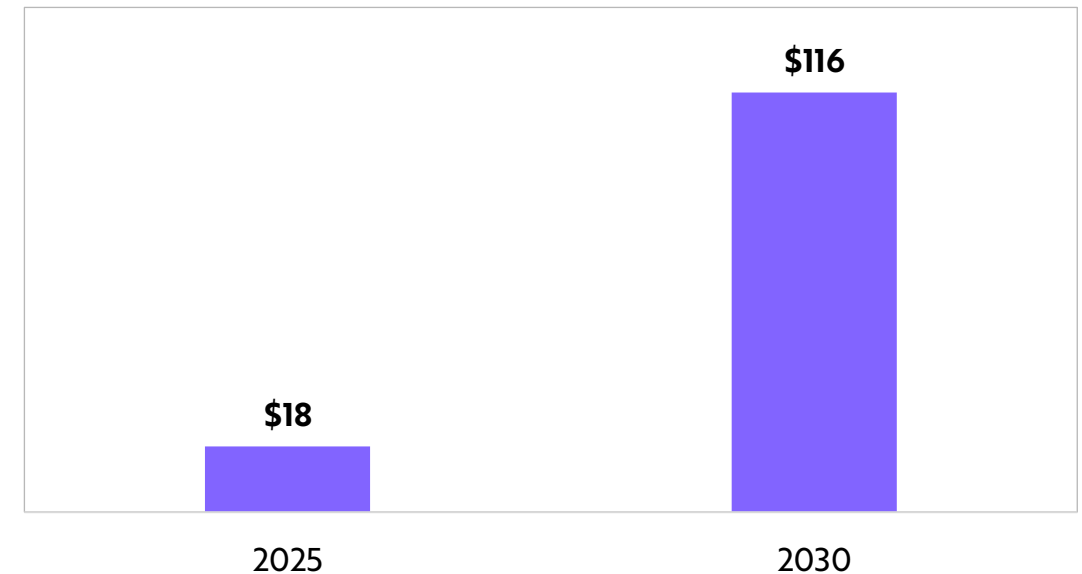
Drones Should Accelerate The Shift To Food Delivery

Online food delivery sales grew more than 40% globally in 2020. According to ARK's research, drone delivery will account for nearly half of the ~40% of food prepared outside of and delivered to the home.

Global Food Delivery as a Share of Food Away From Home



**Global Food Delivery Revenue
(Billions, USD)**



Forecasts are inherently limited and cannot be relied upon.

Source: ARK Investment Management LLC, 2020 based on data sourced from: <https://secondmeasure.com/datapoints/food-delivery-services-grubhub-uber-eats-doordash-postmates/>



SIZING THE OPPORTUNITY

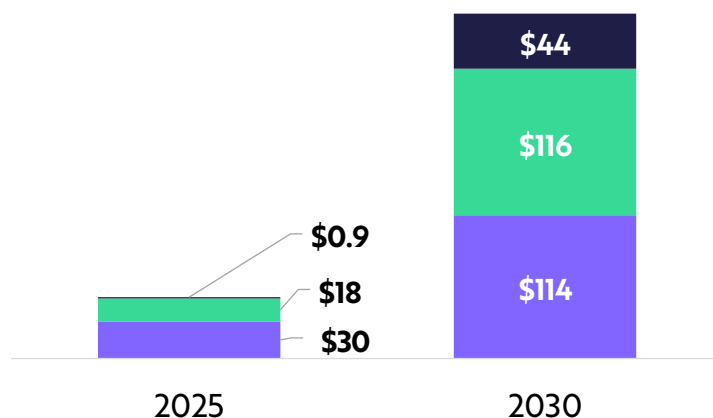
While not yet commercialized, ARK estimates that drone delivery platforms will generate nearly \$50 billion in revenues, \$14 billion in hardware sales, and \$3 billion in mapping revenues by 2025.

By 2030, drone delivery platforms could scale another four-fold, generating ~\$275 billion in revenues, while hardware sales grow nearly three-fold to almost \$50 billion, and mapping revenues nearly four-fold to \$12 billion.

Delivery Revenue

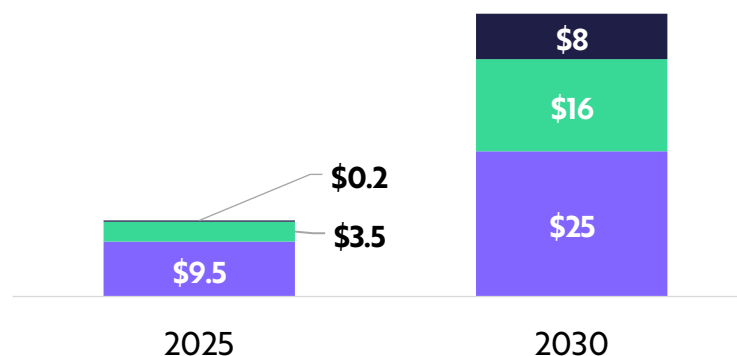
(Billions, USD)

Parcel Drone Food Drone Air Taxi

**Drone Hardware Sales**

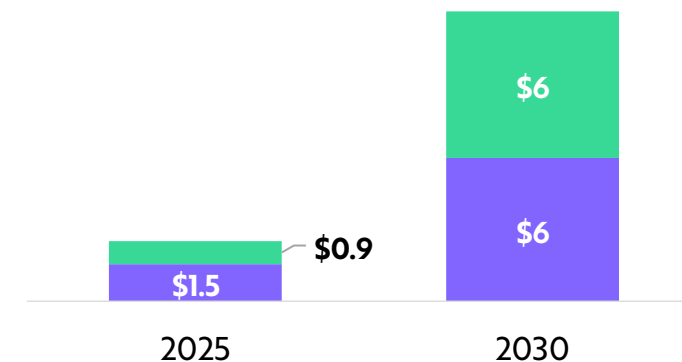
(Billions, USD)

Parcel Drones Food Drones Air Taxis

**Mapping Revenue**

(Billions, USD)

Parcel Drones Food Drones

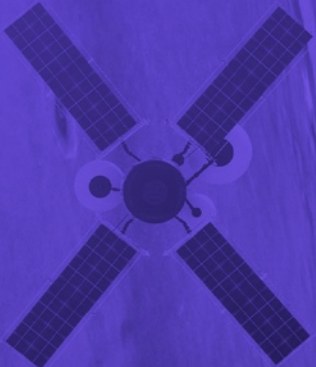




Orbital Aerospace

The Space Industry Is Taking Off

- Rocket and satellite cost declines are upending what once seemed a monopolistic and bureaucratic industry.
- Thanks to advancements in deep learning, mobile connectivity, sensors, 3D printing, and robotics, costs that have been ballooning for decades are beginning to decline. As a result, the number of satellite launches and rocket landings is proliferating.
- **According to ARK's research, the orbital aerospace opportunity – including satellite connectivity and hypersonic flight – will exceed \$370 billion annually.**



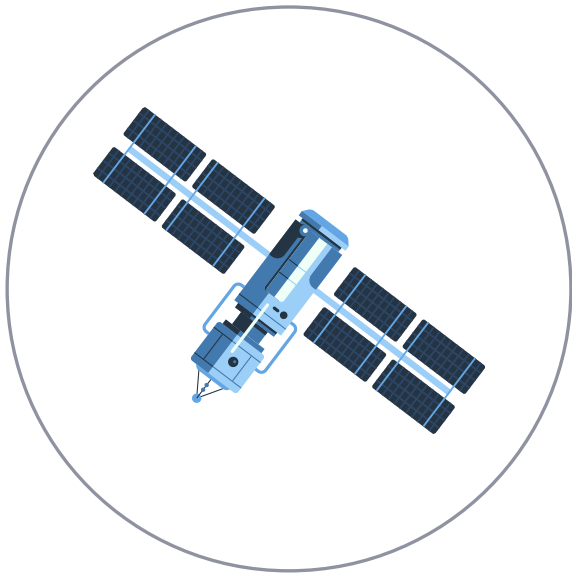
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Orbital Aerospace Is A Big Idea

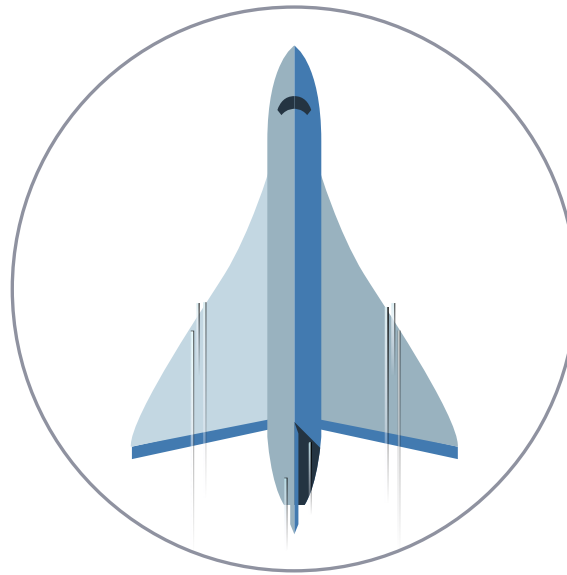
Global Connectivity

Roughly 50% of the global population lacks internet connectivity, but with more satellites, cloud computing will go global.



Hypersonic Point-to-Point Travel

As long-haul flight times collapse from 10+ hours to 2-3 hours, the global economy could transform.



Multiplanetary Species

Humans have been living on the International Space Station for 20 years. Within a decade, humans could inhabit the moon and Mars.



Forecasts are inherently limited and cannot be relied upon.

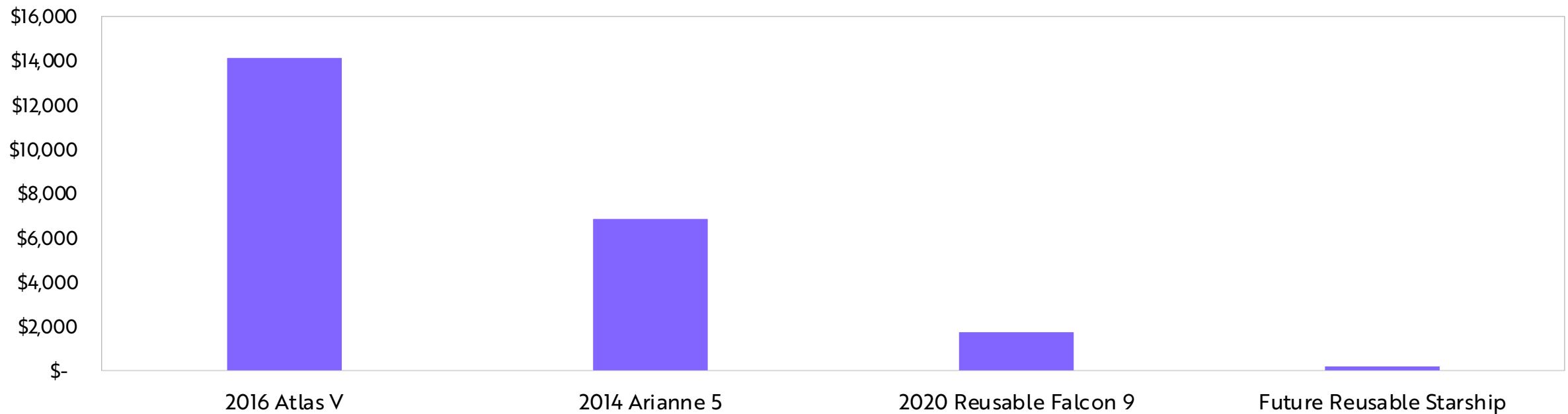
Source: ARK Investment Management LLC, 2020 based on data sourced from: Global connectivity source: https://www.bondcap.com/pdf/Internet_Trends_2019.pdf, ISS source: <https://www.nationalgeographic.com/science/2020/10/humans-have-lived-on-international-space-station-20-years-straight/>.



Rocket Reusability Could Lower The Cost Of Launches By An Order Of Magnitude

Thus far, SpaceX has flown the same Falcon 9 rocket booster eight times successfully.

Rocket Launch Costs
Low Earth Orbit (USD/kg)



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Source: ARK Investment Management LLC, 2020 based on data sourced from: SpaceX, Wayback Machine, web.archive.org/web/20161203124622/, "Discover the Value of Launching on ULA's Atlas V." RocketBuilder, www.rocketbuilder.com/start/configure, Peter B. de Selding — March 18, and Peter B. de Selding. "Former Arianespace Chief Says SpaceX Has Advantage on Cost." SpaceNews, 6 Dec. 2014, spacenews.com/39906former-arianespace-chief-says-spacex-has-advantage-on-cost/, <https://twitter.com/thesheetztweetz/status/1351880498671472641?s=20>.

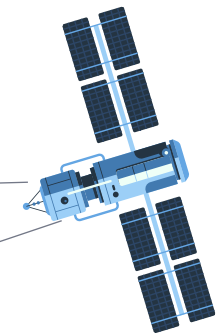
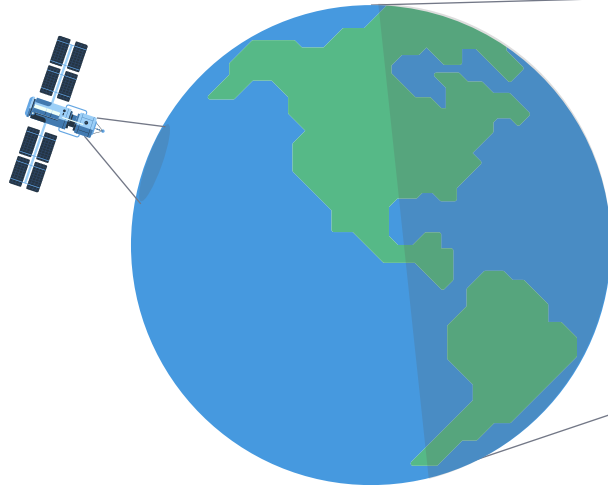


Lower Satellite Launch Costs Could Enable Continuous Global Coverage With Low Latency

While satellites launched into geostationary orbit (GEO) attempted to offer global coverage, latency limited their ability to provide a compelling broadband internet offering. Today, companies are beginning to launch thousands of satellites in low earth orbit (LEO) and enabling continuous global coverage with low latency.

LEO

~300 miles
<40 ms latency*



GEO

~22,000 miles
700 ms latency*

*Note: Latency is measured in milliseconds (ms).

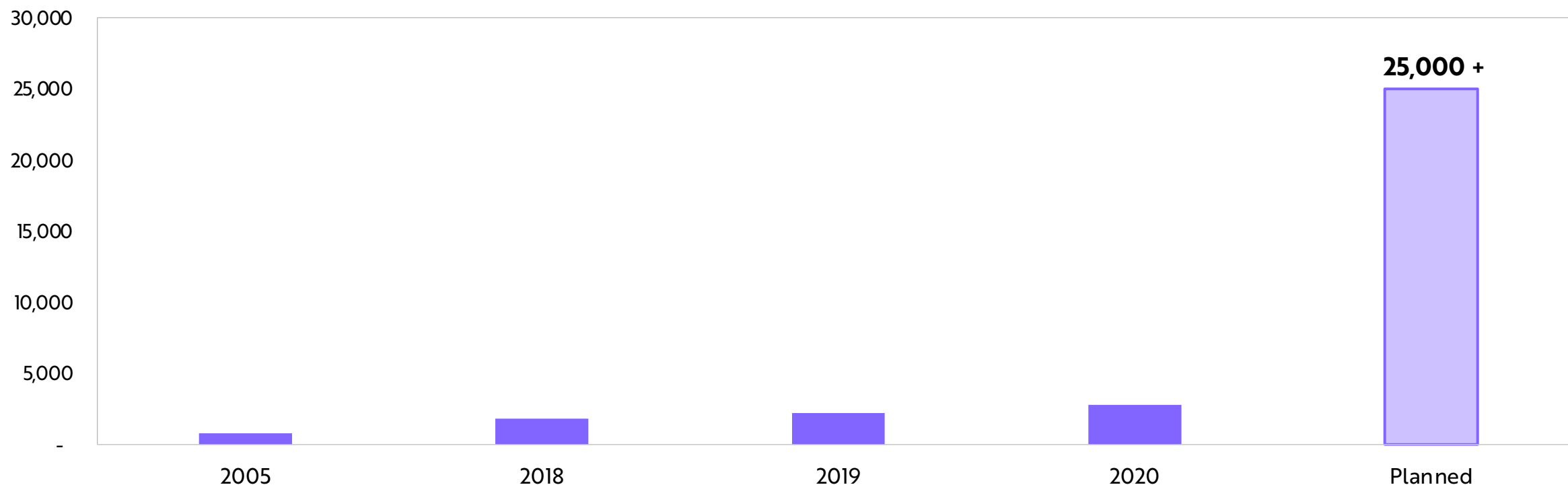
Source: ARK Investment Management LLC, 2020 based on data sourced from: "Satellites 101: LEO vs. GEO." Iridium Satellite Communications, 9 Sept. 2018, www.iridium.com/blog/2018/09/11/satellites-101-leo-vs-geo/, Jon Brodtkin Nov 2, 2020 9:09 pm UTC. "SpaceX Starlink Users Provide First Impressions and 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.



Thanks To Lower Launch Costs, The Number Of Satellites Scheduled For Orbit Has Increased Significantly

Satellites could bolster GDP growth as their networks launch and leverage data for terrestrial businesses.

Number of Active Satellites





SIZING THE OPPORTUNITY

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 a fraction of the total addressable market for satellite broadband.
- The market for connected planes, trains, and motor vehicles is likely to reach \$36 billion in 2025.
- Governments globally are likely to add further to the demand for space services.
- **In total, the satellite connectivity market could approach \$100 billion annually over the medium term.**

$$42 \text{ Million} \div 2.6 \times \$50 \times 12 = \sim \$10 \text{ Billion Annual Addressable Market}$$

Americans without access to broadband People Per Household Average Monthly Broadband Bill Months Per Year

$$3 \text{ Billion} \div 5 \times \$5 \times 12 = \sim \$40 \text{ Billion Annual Addressable Market}$$

People globally without access to broadband People Per Household Monthly Broadband Bill Months Per Year

Forecasts are inherently limited and cannot be relied upon.

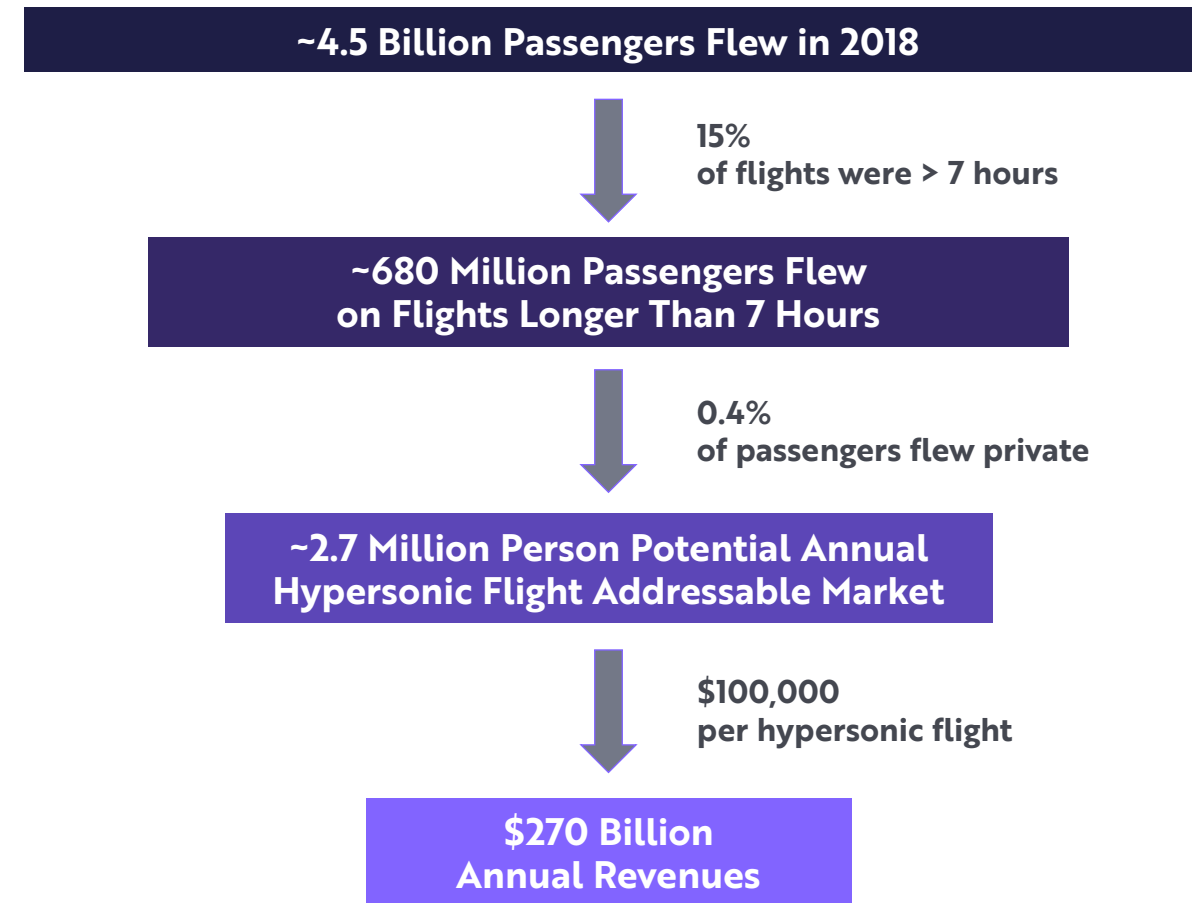
Source: ARK Investment Management LLC, 2020 based on data sourced from: Dreyfuss, Emily. "Global Internet Access Is Even Worse Than Dire Reports Suggest." Wired, Conde Nast, www.wired.com/story/global-internet-access-dire-reports/, "FCC Underestimates Americans Unserved by Broadband Internet by 50%." 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.



SIZING THE OPPORTUNITY

ARK Expects The Demand For Hypersonic Flight To Skyrocket.

- According to our research, passengers on short-haul 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.**



Forecasts are inherently limited and cannot be relied upon.

Source: ARK Investment Management LLC, 2020 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/dougcollan/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.



3D Printing

3D Printing Saves Time, Cost, And Waste While Creating Radically New Part Architectures

- 3D printing is a form of additive manufacturing that builds objects layer-by-layer, as opposed to traditional subtractive manufacturing that removes material from larger blocks.
- 3D printing collapses the time between design and production, shifts power to designers, and reduces supply chain complexity, at a fraction of the cost of traditional manufacturing.
- **ARK believes 3D printing will revolutionize manufacturing, growing at an annual rate of roughly 60% from \$12 billion last year to \$120 billion in 2025.**



12



3D Printing Revenues Declined In 2020, But New Users Leveraged The Technology During The Pandemic

Applications during the COVID-19 crisis:

Medical Devices

- Ventilator Valves
- Mask Connectors for CPAP and BiPAP
- Emergency Respiration Device
- Non-Invasive PEEP Mask

Testing Devices

- Nasopharyngeal (NP) Swabs

Training and Visualization Aids

- Medical Manikins
- Bio-Models

Personal Protective Equipment (PPE)

- Face Shield
- Respirators
- Metal Respirator Filters

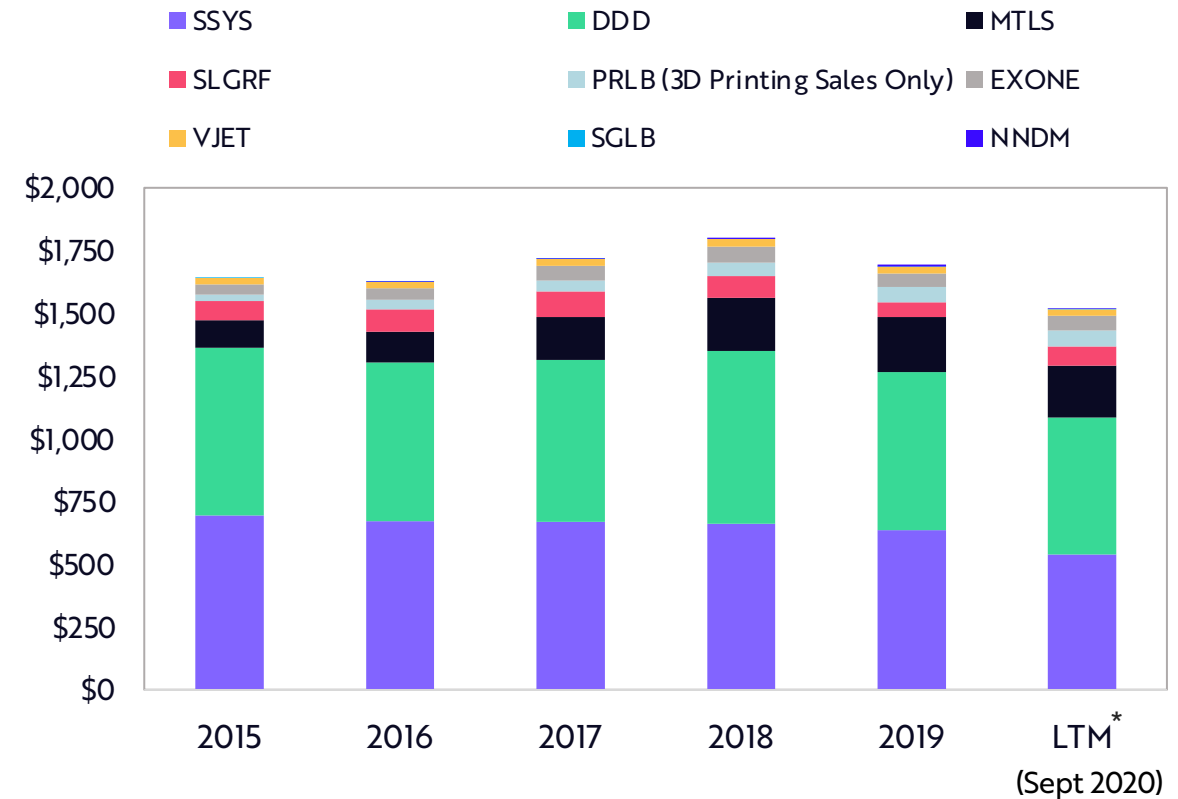
Personal Accessories

- Face Masks
- Mask Filters
- Mask Adjusters
- Door Openers

Emergency Dwellings

- Isolation Wards

3D Printing Sales At Public Companies
(Millions, USD)



*LTM: Last Twelve Months

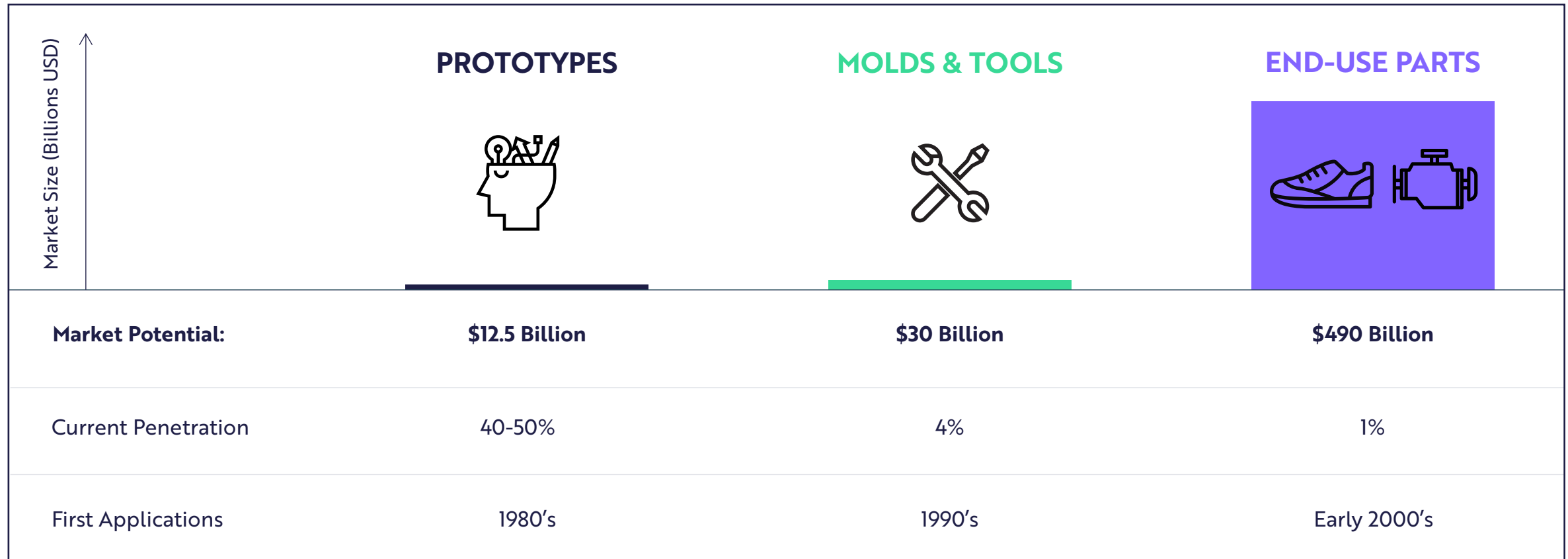
For informational purposes only and should not be considered investment advice, or a recommendation to buy, sell or hold any particular security.

Source: ARK Investment Management LLC, 2020 based on data sourced from: CapitalIQ, Choong, Yu Ying Clarrisa, et al. "The Global Rise of 3D Printing during the COVID-19 Pandemic." Nature News, Nature Publishing Group, 12 Aug. 2020, www.nature.com/articles/s41578-020-00234-3.



3D Printing Is in Its Infancy

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



Forecasts are inherently limited and cannot be relied upon.

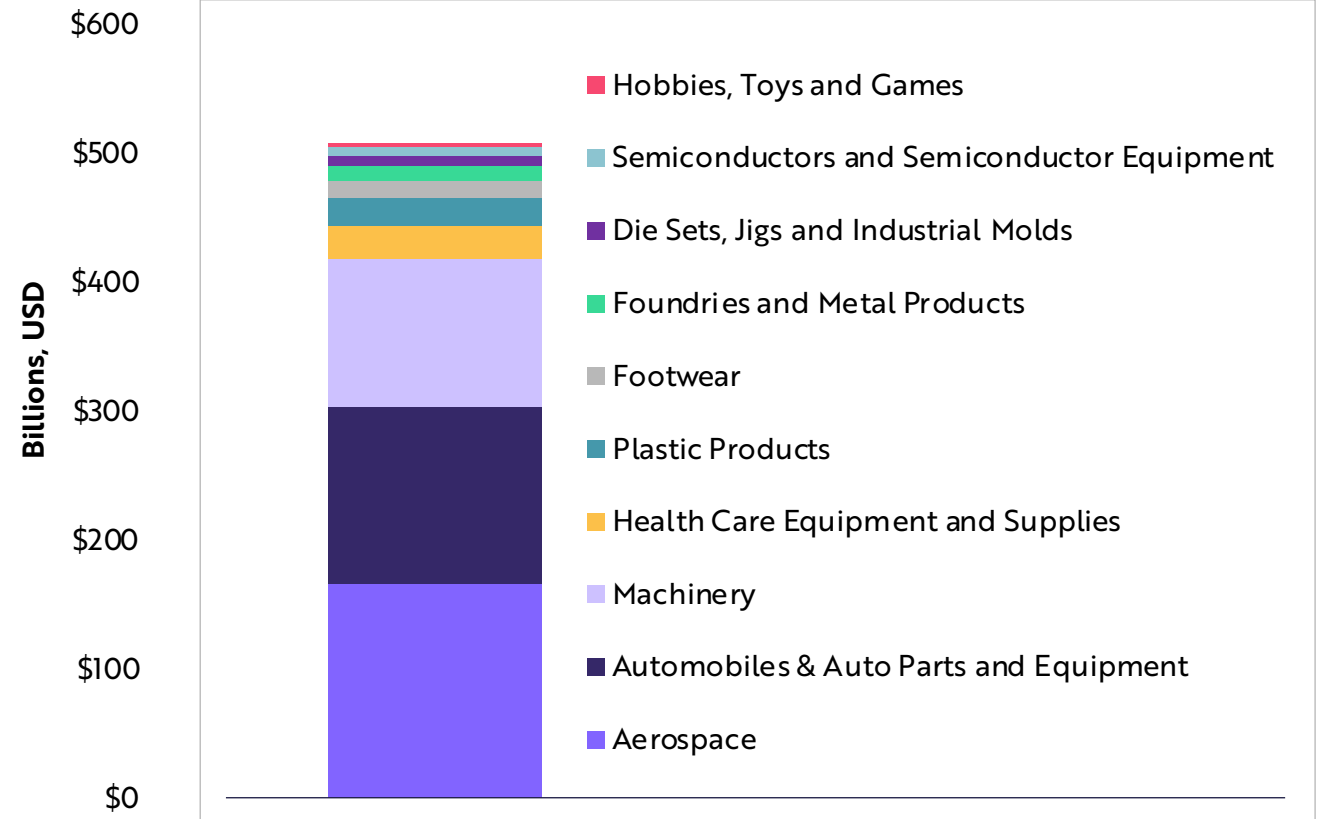
Source: ARK Investment Management LLC, 2020 data sourced from; McKinsey; Stratays; "3D Printing History." AV Plastics, 14 June 2018, <https://arkinv.st/2TC57H1>



3D Printing Applications Vary By Industry, Volumes, And Complexity

Example applications by category:*

- | | |
|--------------------------|---|
| Prototyping | • All Industries |
| Molds & Tools | <ul style="list-style-type: none"> • Automobiles, Auto Parts, and Equipment • Machinery • Foundries and Metal Products • Industrial Manufacturing • Die Sets, Jigs, and Industrial Molds |
| End Use Parts | <ul style="list-style-type: none"> • Aerospace • Health Care Equipment and Supplies • Plastic Products • Footwear • Semiconductors and Equipment |



*Note that industries often span multiple categories
 Source: ARK Investment Management LLC, 2020 based on data sourced from CapitalIQ.



3D Printing Enables Many Form Factors

- Because of autonomous technology and battery breakthroughs, aircraft volumes and designs are proliferating.
- 3D printing is accelerating innovation thanks to low-costs and rapid prototyping. It lowers the weight of low volume, highly complex parts, saving significant costs. The aerospace industry should be a prime beneficiary.
- ARK estimates that drone hardware revenues will total roughly \$100 billion by 2025.

Drones Take Many Shapes



Forecasts are inherently limited and cannot be relied upon.

Source: ARK Investment Management LLC, 2020. Image Sources: TransportUp, <https://medium.com/nuro/faces-and-fascia-a-discussion-with-nuros-design-team-b7a2fe2a3a74>, <https://thespoon.tech/starship-raises-25-million-to-roll-out-more-delivery-robots/>, <https://www.cnet.com/news/amazons-new-ring-camera-is-actually-a-flying-drone-for-inside-your-home/>, https://i.etsystatic.com/16561342/d/i/i/03d9c2/1413053916/i1_340x270.1413053916_msed.jpg?version=0



3D Printing Unlocks The Full Potential Of Artificial Intelligence In Manufacturing

The convergence of 3D printing and artificial intelligence enables highly optimized designs not possible in traditional manufacturing.



US Air Force Institute of Technology

Cubesat Bus

- 125 parts into 1 part
- 50% lighter
- 20% stiffer
- 6X reduction in failure locations



HEXR

Custom Helmet Insert

- 60% more shock-absorbent
- 25% reduction in rotational forces to head
- 45% reduction in rotational velocity to head



Yamaichi Special Steel

Brake Caliper

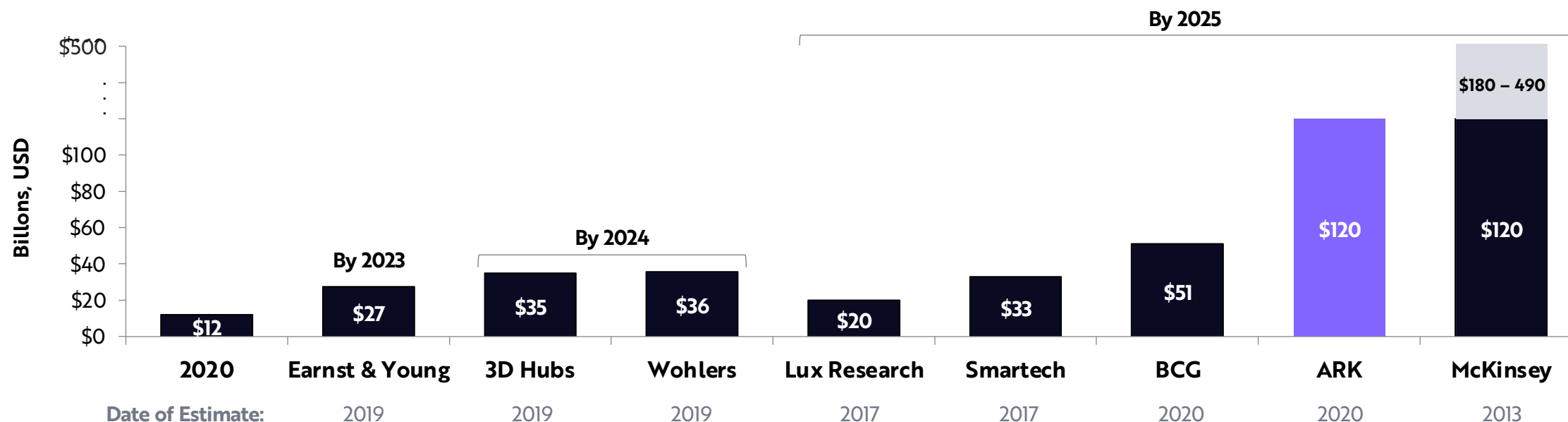
- 40% lighter
- Better airflow
- Better pressure distribution



SIZING THE OPPORTUNITY

ARK believes that the global 3D printing market will scale at a compound annual rate of 60% during the next five years, from \$12 billion to roughly \$120 billion by 2025.

Global Estimates for 3D Printing Market 2020 to 2025



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, 2020 based on data sourced from 3D Printing Trends 2020: Industry Highlights and Market Trends. 3D Hubs Manufacturing LLC, 2020, www.3dhubs.com. "EY's Global 3D Printing Report 2019." Ey.com/De, Ernst & Young GmbH, Oct. 2019. McCue, TJ. "Significant 3D Printing Forecast Surges To \$35.6 Billion." Forbes, Forbes Magazine, 3 Apr. 2019, www.forbes.com/sites/tjmccue/2019/03/27/wohlers-report-2019-forecasts-35-6-billion-in-3d-printing-industry-growth-by-2024/#121d7a9d7d8a, The 3D printing market will quadruple to US\$12 billion by 2025. "3D Printing Market to Quadruple to \$12 Billion in 2025" [press release], Lux Research, April 29, 2014, <http://www.luxresearchinc.com/news-and-events/press-releases/read/3d-printing-market-quadruple-12-billion-2025> "SmarTech Analysis Annual Additive Manufacturing Market Summary Report Says AM Market Grew to Over \$10B Worldwide in 2019." Attachment, www.globenewswire.com/NewsRoom/AttachmentNg/2bfad03b-3edd-4c69-b0a5-e83ca835ea6e/en. Küpper, Daniel, et al. "Get Ready for Industrialized Additive Manufacturing." BCG Global, BCG Global, 8 Jan. 2021, www.bcg.com/publications/2017/lean-manufacturing-industry-4.0-get-ready-for-industrialized-additive-manufacturing. Manyika, James, et al. "Disruptive Technologies: Advances That Will Transform Life, Business, and the Global Economy." McKinsey & Company, McKinsey & Company, 1 Mar. 2013, www.mckinsey.com/insights/business_technology/disruptive_technologies.



Long-Read Sequencing

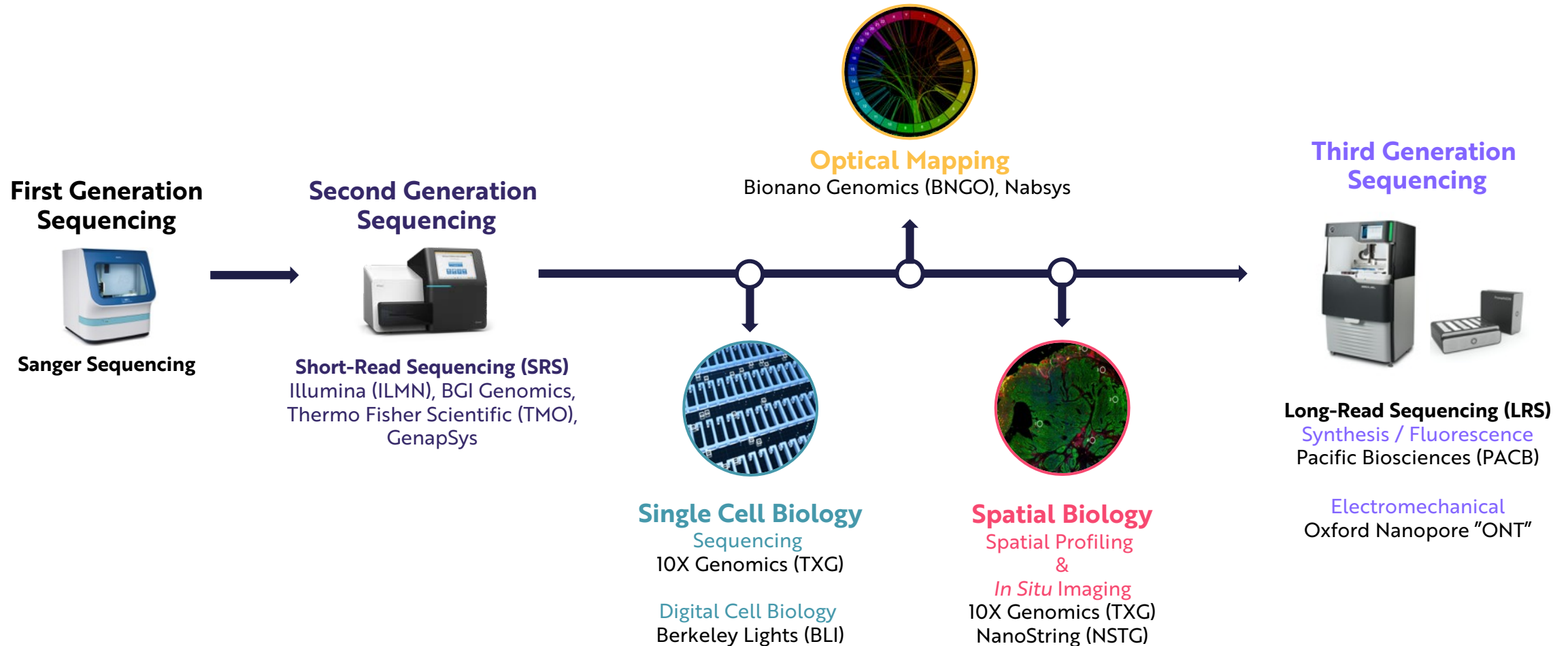
Long-Read Sequencing Could Provide A More Complete Picture Of The Human Genome

- Next-generation DNA sequencing (NGS) is the driving force behind the genomic revolution. Though historically dominated by short-read sequencing, we believe long-read sequencing will gain share at a rapid rate.
- ARK believes long-read technology offers superior accuracy, more comprehensive variant detection, and a richer set of features than short-read platforms. By the end of 2025, highly-accurate long and short-read sequencing should approach cost-parity.
- **We estimate that long-read revenues will grow 82% at an annual rate, from \$250 million in 2020 to roughly \$5 billion in 2025.**

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



The Genomic 'Toolkit' Is Expanding To Provide A Fuller, Richer, And More Accurate View Into Biology

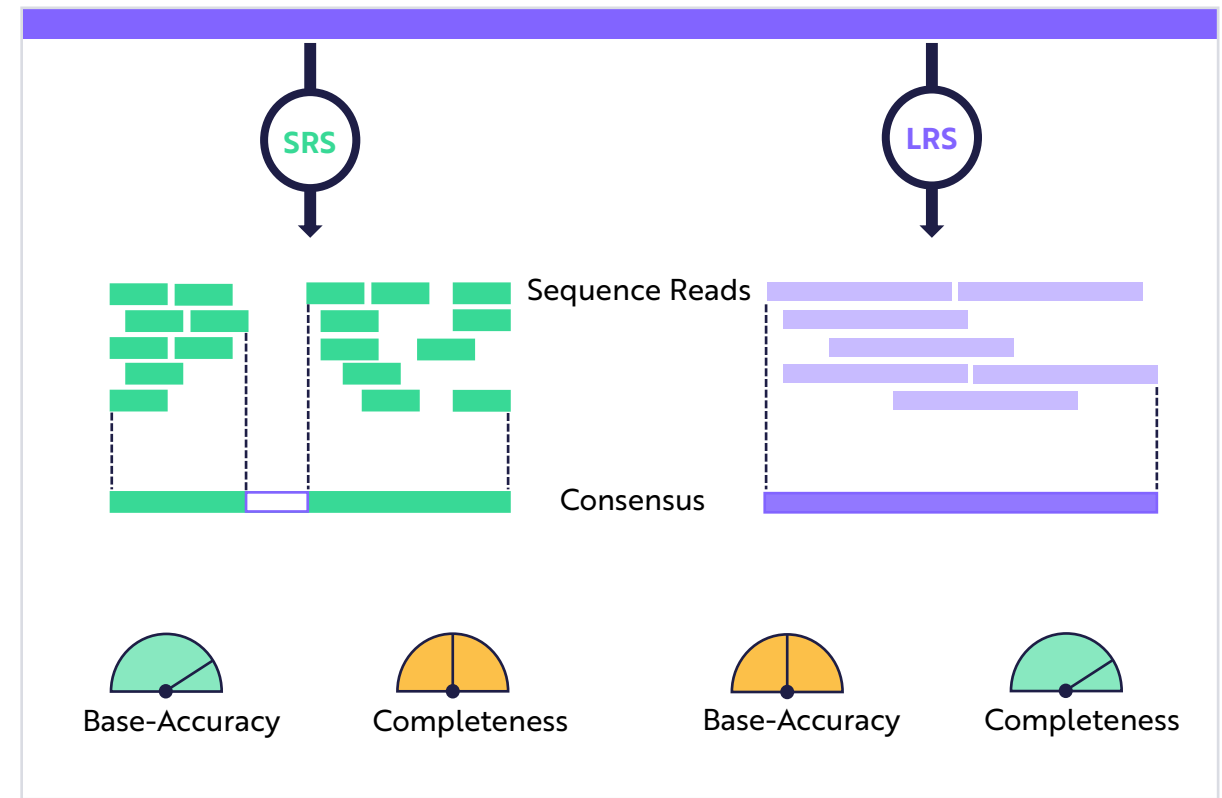




Historically, Researchers Had To Choose Between Accuracy With SRS Or Comprehensiveness With LRS

- Both LRS and SRS systems (a) break the genome into smaller fragments, (b) analyze the fragments with high-resolution optics,* and (c) reassemble the genome with efficient computer algorithms.¹
- SRS blends many small (150-bp) fragments, called reads, into a consensus sequence. This method captures small mutations but does not detect larger reshufflings, called structural variants, or mutations hidden in repetitive genomic regions (e.g. AAAA).¹
- Older LRS systems measured larger (>10,000-bp) reads and, while less accurate on a per-base level, provided a more complete picture of the genome.¹

Gene (*CYP2D6* as an example)



*Applies to Pacific Biosciences of California (PACB) and Bionano Genomics (BNGO). Oxford Nanopore Technologies calls bases using fluctuations in electric voltage/current across a nanopore channel. For informational purposes only and should not be considered investment advice, or a recommendation to buy, sell or hold any particular security.

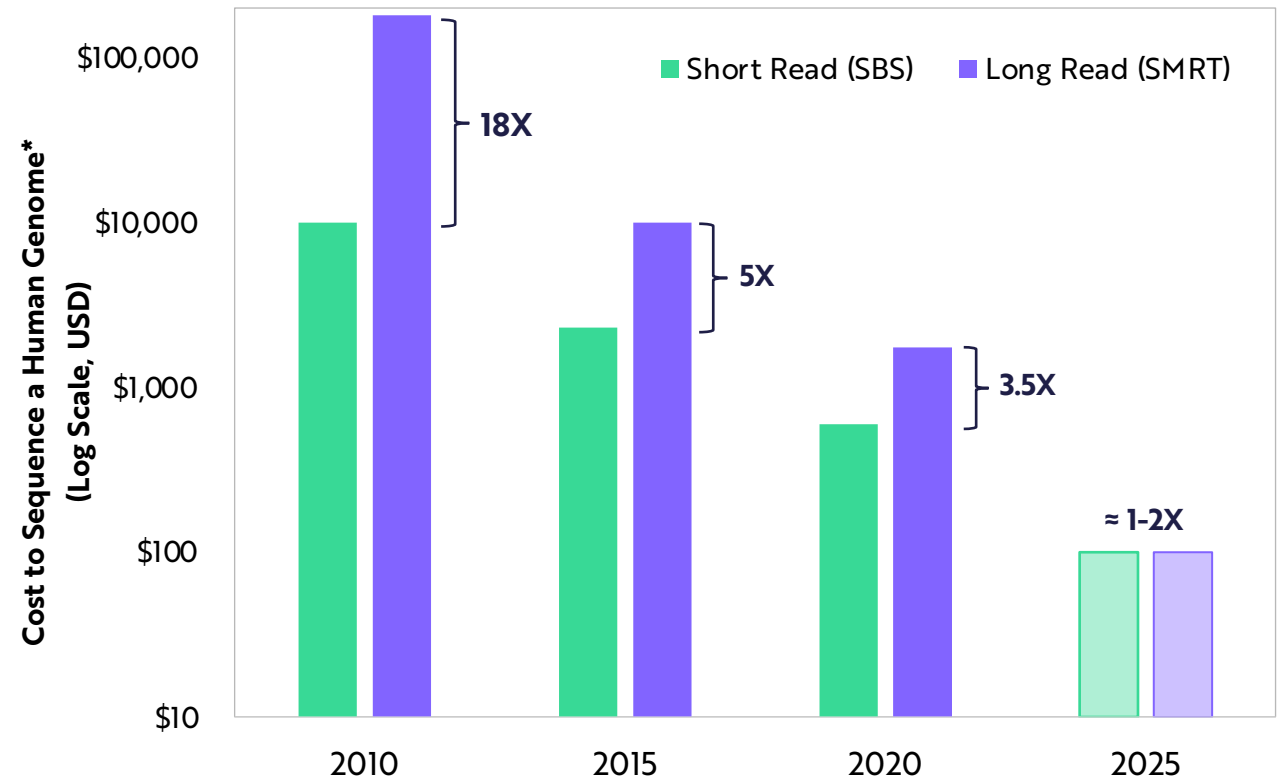
Source: ARK Investment Management LLC, 2020. [1] Pollard, Martin O, et al. "Long Reads: Their Purpose and Place." Human Molecular Genetics, vol. 27, no. R2, 2018, doi:10.1093/hmg/ddy177.



As Costs For LRS Converge With SRS, Many Clinical Applications Could Shift To LRS

- Catalyzed by deep learning algorithms, such as Google's (GOOGL) DeepVariant, both synthesis and nanopore-based LRS methods rapidly could improve in performance.¹
- Though less accurate on a per-base level currently, nanopore-based LRS can generate whole human genome sequences for ~\$500—more cost effectively than SRS.²
- Though more expensive, according to results obtained from the PrecisionFDA Truth Challenge V2, synthesis-based LRS is 2.5X more accurate than SRS and 30X more accurate than nanopore-based LRS.³

Synthesis-Based LRS and SRS Could Near Cost-Parity by 2025



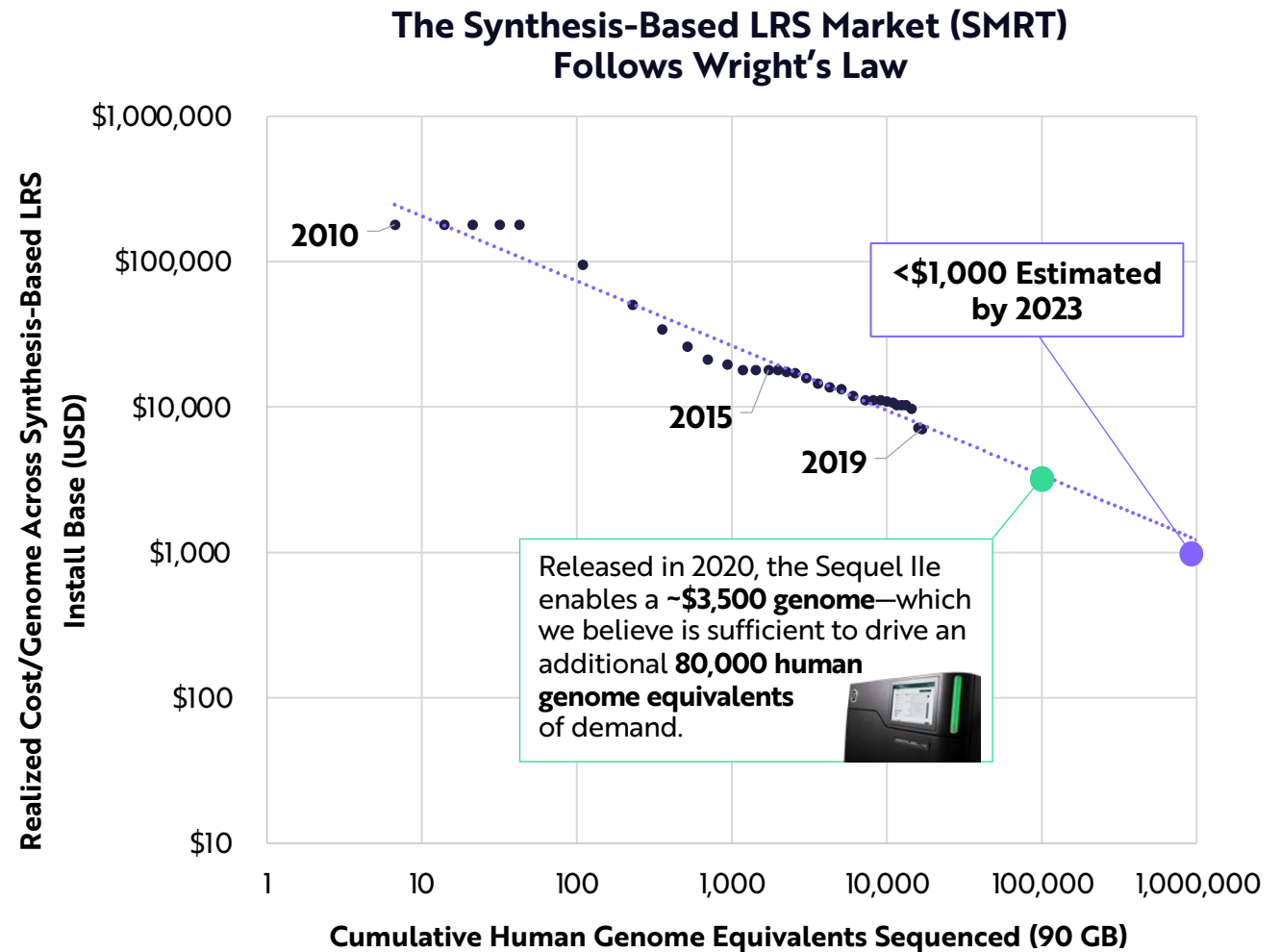
*Specifically, Pacific Bioscience's HiFi chemistry, which sits on top of the company's SMRT (Single Molecule Real Time) platform.

**Assumes equivalent variant calling performance as measured by precision and recall (F1); 30X coverage for Illumina (2010-2025); 30X coverage for PacBio (2010-2015) and 20X coverage for PacBio (2020-2025). 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, 2020. [1] Baid, Gunjan, et al. "An Extensive Sequence Dataset of Gold-Standard Samples for Benchmarking and Development." BioRxiv, Cold Spring Harbor Laboratory, 1 Jan. 2020, www.biorxiv.org/content/10.1101/2020.12.11.422022v1. [2] "Product Comparison." Oxford Nanopore Technologies, 2 Dec. 2020, nanoporetech.com/products/comparison. [3] "PrecisionFDA Truth Challenge V2: Calling Variants from Short and Long Reads in Difficult-to-Map Regions." Truth Challenge V2: Calling Variants from Short and Long Reads in Difficult-to-Map Regions – PrecisionFDA, precision.fda.gov/challenges/10/view/results.



According To Wright's Law, For Every Cumulative Doubling In Data Produced On Its Installed Base, The Cost Of Synthesis-Based LRS Has Declined And Will Continue To Decline By 28%

- Driven primarily by improvements in cost and throughput, LRS's unique capabilities should galvanize broader adoption.^{1,2,3} LRS (a) does not require amplification, (b) will detect methylation natively, and (c) will span full RNA molecules.
- According to ARK's estimates, the cost to sequence a whole human genome with long-read technology will drop to \$100-\$200, its accuracy superior to SRS across all variant types by the end of 2025.



Forecasts are inherently limited and cannot be relied upon.

For information 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, 2020. [1] SW. Cho, S. Kim, et al. "Amplification-Free Long-Read Sequencing Reveals Unforeseen CRISPR-Cas9 off-Target Activity." *Genome Biology*, BioMed Central, 1 Jan. 2020, genomebiology.biomedcentral.com/articles/10.1186/s13059-020-02206-w. [2] D. Gordon, J. Huddleston, et al. "Accurate Targeted Long-Read DNA Methylation and Hydroxymethylation Sequencing with TAPS." *Genome Biology*, BioMed Central, 1 Jan. 2020, genomebiology.biomedcentral.com/articles/10.1186/s13059-020-01969-6. [3] Uapinyoying, Prech, et al. "A New Long-Read RNA-Seq Analysis Approach Identifies and Quantifies Novel Transcripts of Very Large Genes." *BioRxiv*, Cold Spring Harbor Laboratory, 1 Jan. 2020, www.biorxiv.org/content/10.1101/2020.01.08.898627v1.full#:~:text=Long%2Dread%20sequencing%20technologies%20such,2017.



ARK Believes That LRS Analytics Are Superior For Many Sequencing Applications

- Some clinical applications, such as rapid whole genome sequencing (WGS) within the pediatric intensive care setting, have high reimbursement rates—giving diagnostic providers more flexibility to switch to LRS.¹
- Genetic variants of all sizes—from small to large—both in easy and hard-to-sequence genomic regions, can impact a patient's phenotype. In ARK's view, LRS tools provide the most comprehensive variant detection, regardless of sequence context.²



Pediatric cancers have unique molecular drivers such as hidden single-nucleotide variants (SNVs), gene fusions, structural variants, and methylation—all more amenable to LRS and optical mapping instruments.³



Many **rare diseases**, which affect 350 million people globally, are genetic in origin. Short-read WGS surfaces <50% of the causes, forcing many patients into a diagnostic odyssey.⁴



Common **hereditary diseases**, especially those neurological in origin, have ambiguous clinical presentations which LRS can diagnose.⁵



Studying **structural variations** in a population and across diverse groups is vital to increasing the accuracy of molecular diagnostics.

Source: ARK Investment Management LLC, 2020. [1] Reporter, Staff. "Blue Shield of California to Cover Rady Children's Rapid Whole-Genome Sequencing Test." GenomeWeb, 9 Mar. 2020, www.genomeweb.com/molecular-diagnostics/blue-shield-california-cover-rady-childrens-rapid-whole-genome-sequencing-test. [2] "Overview of Structural Variation." National Center for Biotechnology Information, US National Library of Medicine, www.ncbi.nlm.nih.gov/dbvar/content/overview/. [3] Wong, M., Mayoh, C., Lau, L.M.S. et al. Whole genome, transcriptome and methylome profiling enhances actionable target discovery in high-risk pediatric cancer. Nat Med 26, 1742–1753 (2020). <https://doi.org/10.1038/s41591-020-1072-4>. [4] Mitsuhashi, S., Matsumoto, N. Long-read sequencing for rare human genetic diseases. J Hum Genet 65, 11–19 (2020). <https://doi.org/10.1038/s10038-019-0671-8> [5] Posey, J.E. Genome sequencing and implications for rare disorders. Orphanet J Rare Dis 14, 153 (2019). <https://doi.org/10.1186/s13023-019-1127-0>.

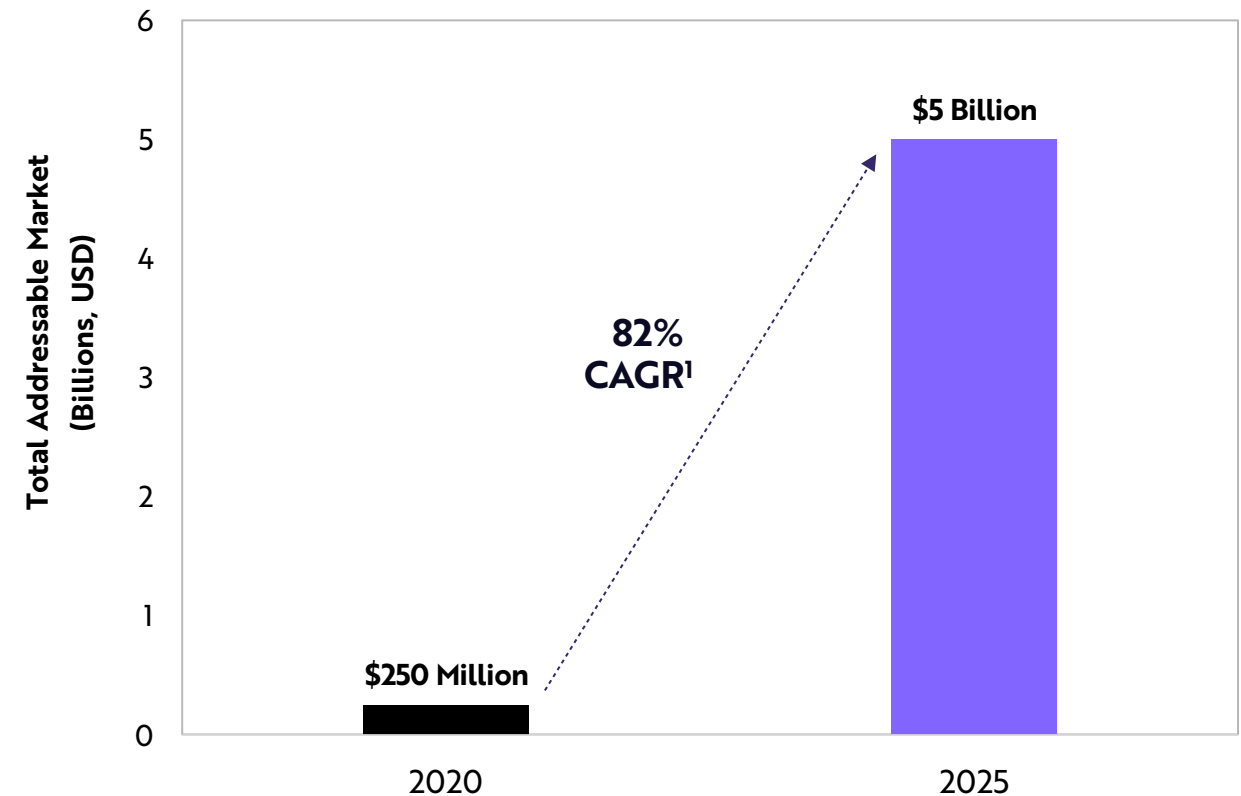


SIZING THE OPPORTUNITY

ARK Expects The LRS Market* To Grow At An Annual Rate Of 82% Through 2025.

- ARK believes that the demand for LRS is reaching an inflection point, driven by lower sequencing costs and the need for highly-accurate and complete results.
- **Including sequencing consumables, instruments, and services, LRS revenues could expand from \$250 million to \$5 billion by 2025.**
- SRS will continue to dominate the sequencing market, especially as liquid biopsy becomes a standard of care in oncology.

LRS Market Size
(Subset of Overall Sequencing Market)



*Inclusive of all third-generation sequencing providers. [1] 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.



Multi-Cancer Screening

Liquid Biopsies Could Prevent More Cancer Deaths Than Any Medical Intervention in History

- According to ARK's research, the convergence of innovative technologies has pushed the cost of multi-cancer screening down by 20-fold from \$30,000 in 2015 to \$1,500 today and it should drop another 80%+ to \$250 in 2025.
- **As a result, the multi-cancer screening market should scale to \$150 billion in the US. A multi-cancer screening protocol could avert 66,000 cancer deaths per year in the US, saving 1.4 million human life years.**

"An ounce of prevention is worth a pound of cure."

Benjamin Franklin

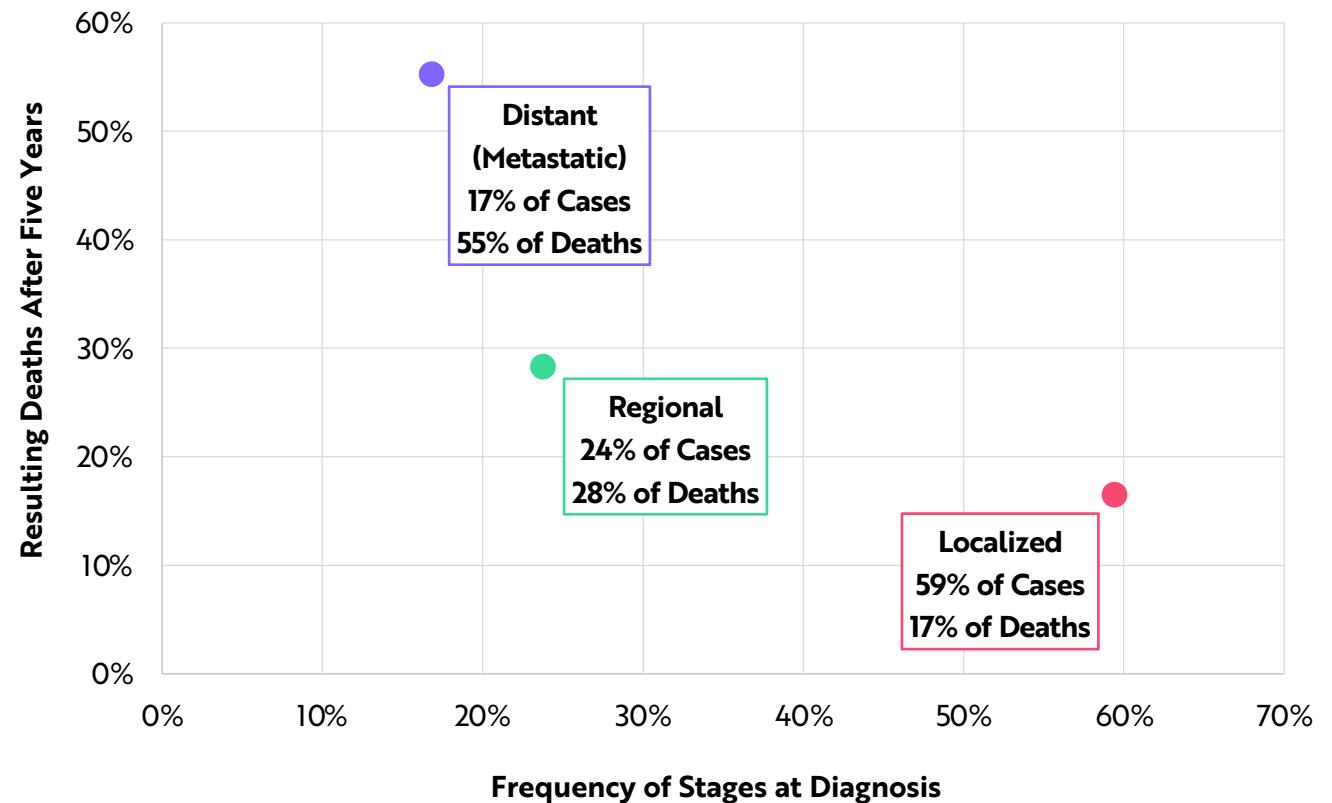
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Diagnosed Early, Cancer Can Be Treated Successfully

- All solid tumors follow a predictable path from local and treatable to metastatic and lethal, providing the rationale for earlier detection.¹
- Metastatic cancers comprise just 17% of new cases but cause 55% of all cancer deaths over a five-year period.²
- The weighted-average five-year survival rate for localized cancers is 89%,³ but only 24% for metastatic cancers.²

Distant (Metastatic) Cancers Are the Minority of New Cases But the Majority of Deaths

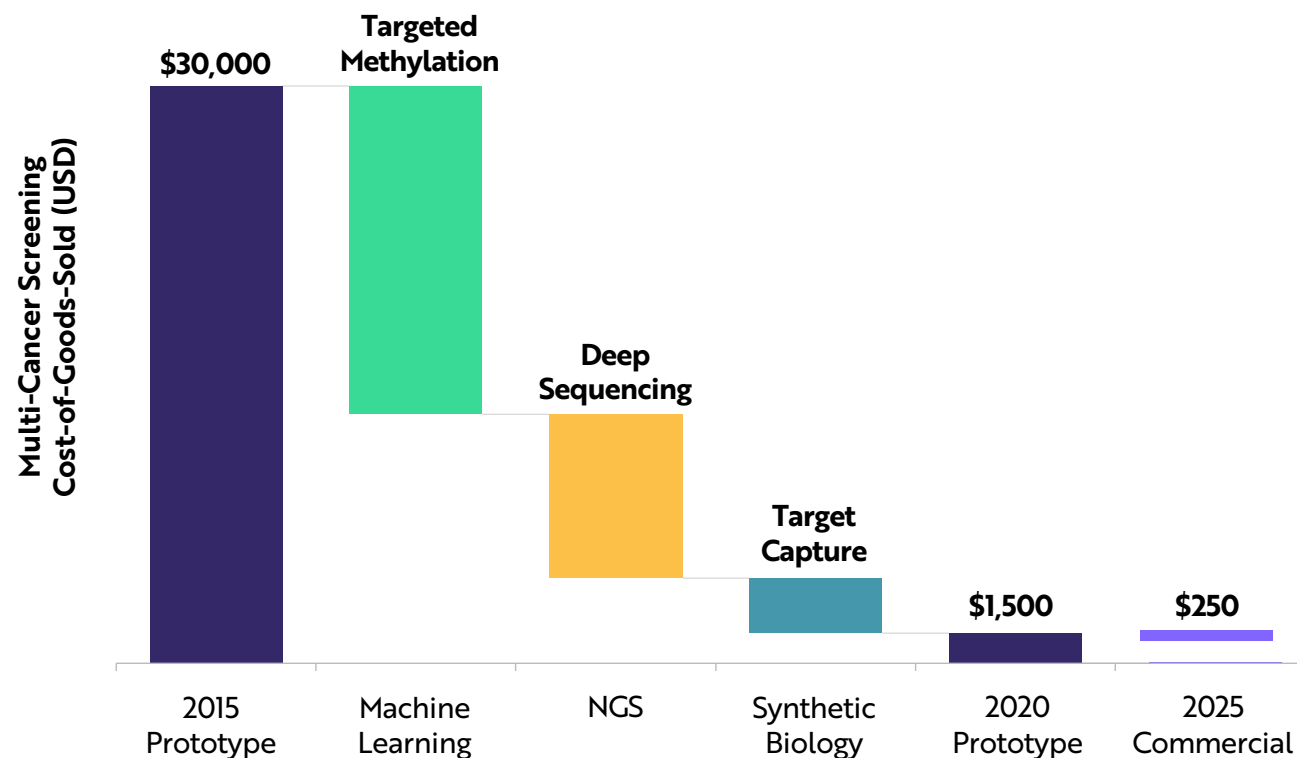




Based On A Single Blood Test, Multi-Cancer Screening Can Detect Dozens Of Early-Stage Cancers

- Along with somatic mutations, circulating proteins, and immune signatures, machine learning algorithms have surfaced DNA methylation as a novel and highly sensitive biomarker for earlier cancer detection.¹
- The rapid cost decline of next-generation DNA sequencing (NGS) is enabling liquid biopsies.²
- Advancements in synthetic biology are helping clinicians to find faint signals of cancer in high-noise environments like the bloodstream.³

The Combination of Innovative Technologies
is Driving Down Screening Costs
(2015-2025)



Forecasts are inherently limited and cannot be relied upon.

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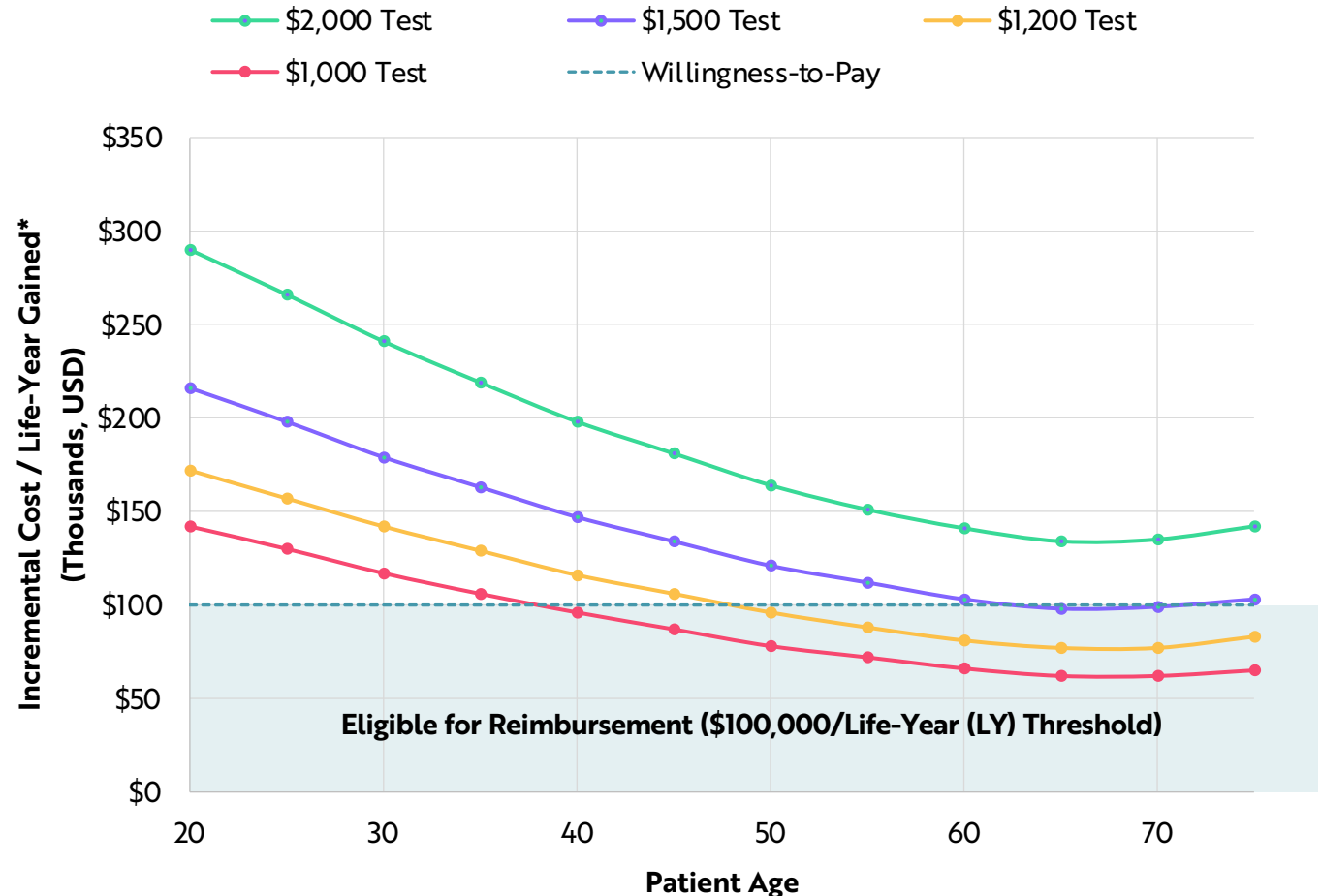
Source: ARK Investment Management LLC, 2020. [1] Liu, M.c., et al. "Sensitive and Specific Multi-Cancer Detection and Localization Using Methylation Signatures in Cell-Free DNA." *Annals of Oncology*, vol. 31, no. 6, 2020, pp. 745-759, doi:10.1016/j.annonc.2020.02.011. [2] Illumina. "Illumina Announces the NovaSeq™ 6000 v1.5 Reagent Kit Unlocking Deeper Discoveries with the \$600 Genome." *Illumina*, 2020, www.illumina.com/company/news-center/press-releases/2020/9c48adf5-5b78-4e18-8116-3c7c8b3ad79f.html. [3] Twist Bioscience. "Targeted Methylation Sequencing." *Twist Bioscience*, 2020, www.twistbioscience.com/resources/application-note/targeted-methylation-sequencing.



Thanks To Rapidly Declining Costs, Multi-Cancer Screening Is Approaching A Reimbursable Price Point

- As population-scale clinical utility data proliferates, ARK believes a \$1,500 price tag will unlock the multi-cancer screening market for those aged 65 to 80—the age range in which the incidence of cancer peaks.
- As prices drop below \$1,000, nearly all age groups above 40 years could be screened for cancer cost-effectively, potentially saving up to 1.4 million human life years in the US alone.

The Multi-Cancer Screening Market:
Costs and Reimbursement



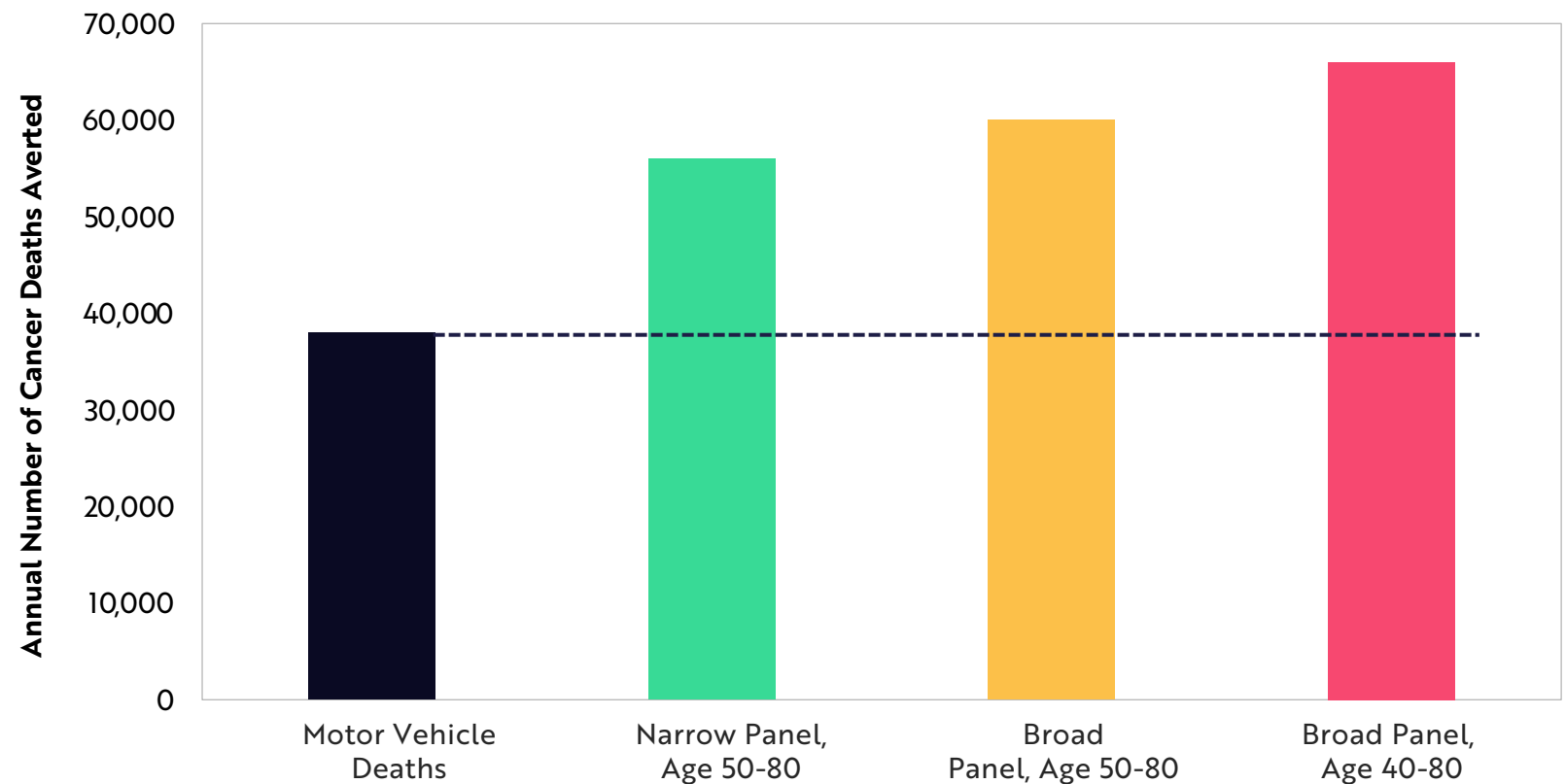
*Life Years gained is a modified mortality measure where remaining life expectancy is considered. Forecasts are inherently limited and cannot be relied upon.
Source: ARK Investment Management LLC., 2020



Multi-Cancer Screening Could Prevent Roughly 66,000 Cancer Deaths Annually In The US

- Routine blood-based, multi-cancer screening combined with improvements in single-cancer screening could prevent 40% of metastatic diagnoses and increase loco-regional diagnoses by 10%.
- Even without improvements in cancer therapy, ARK estimates that earlier intervention could prevent 66,000 cancer deaths per year in the US alone.

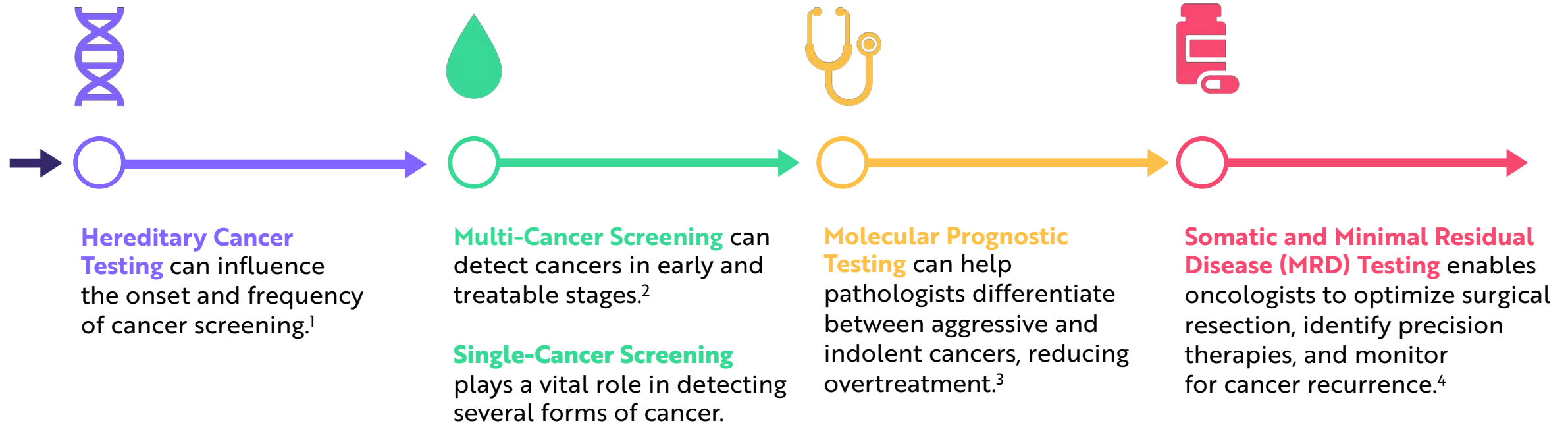
Earlier Detection Could Lower Cancer Mortality



Note: Narrow panels seek to detect a limited number of cancers, typically about a dozen (12). Broad panels, or pan-cancer panels, aim to find as many as fifty different cancers. Forecasts are inherently limited and cannot be relied upon. | Source: ARK Investment Management LLC, 2020



Multi-Cancer Screening And Other Genomic Technologies Are Transforming Oncology



Source: ARK Investment Management LLC, 2020. [1] Hu, Chunling, et al. "The Contribution of Germline Predisposition Gene Mutations to Clinical Subtypes of Invasive Breast Cancer From a Clinical Genetic Testing Cohort." JNCI: Journal of the National Cancer Institute, 2020, doi:10.1093/jnci/djaa023. [2] Lennon, Anne Marie, et al. "Feasibility of Blood Testing Combined with PET-CT to Screen for Cancer and Guide Intervention." Science, vol. 369, no. 6499, 2020, doi:10.1126/science.abb9601. [3] "Our Products." Our Products, 2020, www.veracyte.com/our-products. [4] "Personalized Cancer Monitoring." Edited by ArcherDx, Personalized Cancer Monitoring, 14 Aug. 2020, archerdx.com/diagnostic-products/personalized-cancer-monitoring/.

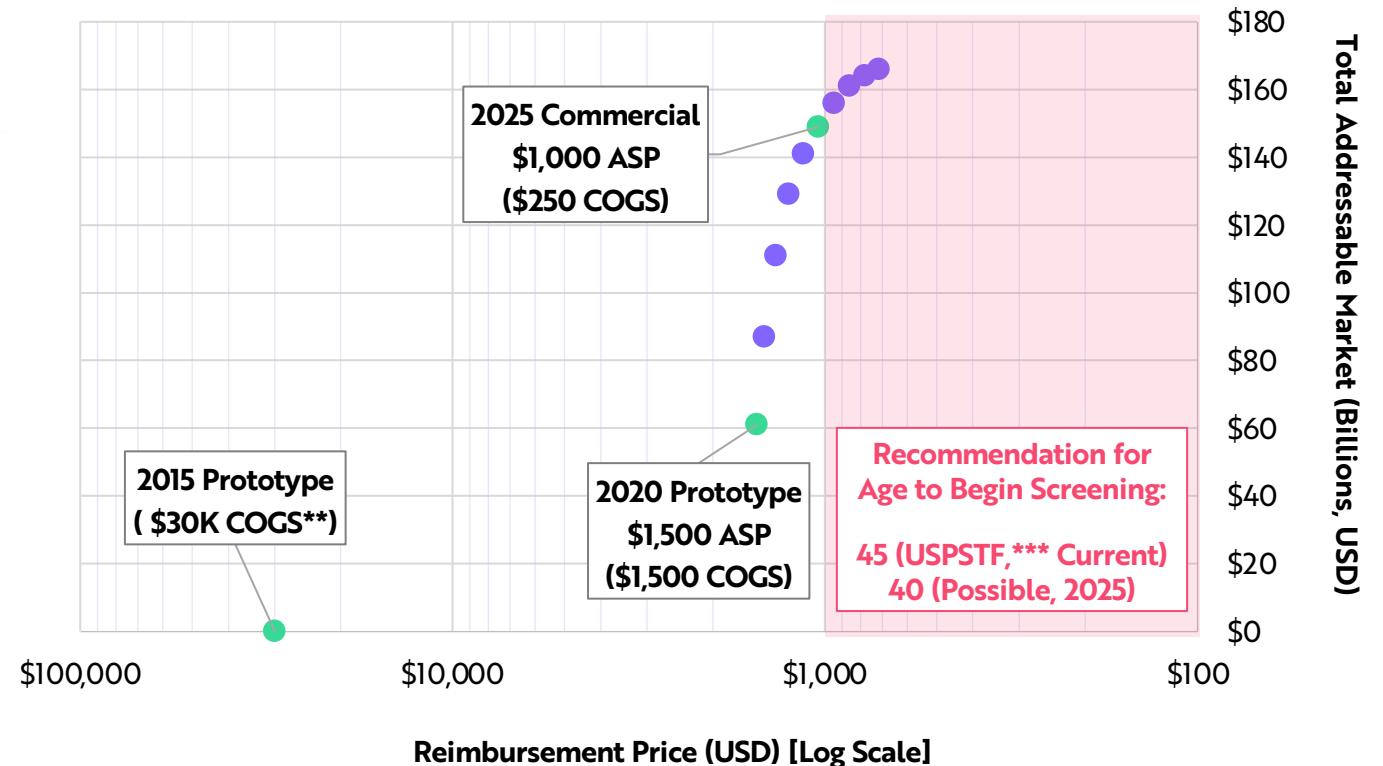


SIZING THE OPPORTUNITY

While a \$1,500 unit price could unlock the market, a \$1,000 unit price could transform the cancer mortality curve.

- The convergence between and among innovative technologies has pushed the cost of multi-cancer screening down by 20-fold from \$30,000 in 2015 to \$1,500 today and, according to ARK's research, by another 80% to \$250 in 2025.
- **If fully adopted, multi-cancer screening should scale to a \$150 billion market* in the US alone.**

Multi-Cancer Screening is Potentially One of the Largest Genomics Markets¹



*A \$150 billion market opportunity is dependent upon high patient adherence to all screening guidelines inclusive of multi- and single-cancer screening modalities. Screening providers likely will price lower than the top of the reimbursement envelope to accelerate system adoption and enable other payment options—such as patient pay. Finally, we expect that comprehensive germline testing is a prerequisite to screening persons younger than age 40.

COGS: Cost of Goods Sold. * USPSTF: A volunteer group of health experts who review published research and make recommendations about prevention health care methods such as screening tests, counseling, immunizations, and medicines. Forecasts are inherently limited and cannot be relied upon.

Source: ARK Investment Management LLC, 2020 based on data sourced from <https://www.medpagetoday.com/hematologyoncology/coloncancer/89352>. [1] United States Preventive Services Task Force (USPSTF).



Cell and Gene Therapy: Generation 2

Cell And Gene Therapies Are In Early Days

- The second generation of cell and gene therapies should shift from:
 - liquid to solid tumors
 - autologous to allogeneic cell therapy¹
 - ex vivo to in vivo gene editing²
- **New cell and gene therapy innovations could increase the total addressable market for oncology therapeutics by more than 20-fold.**

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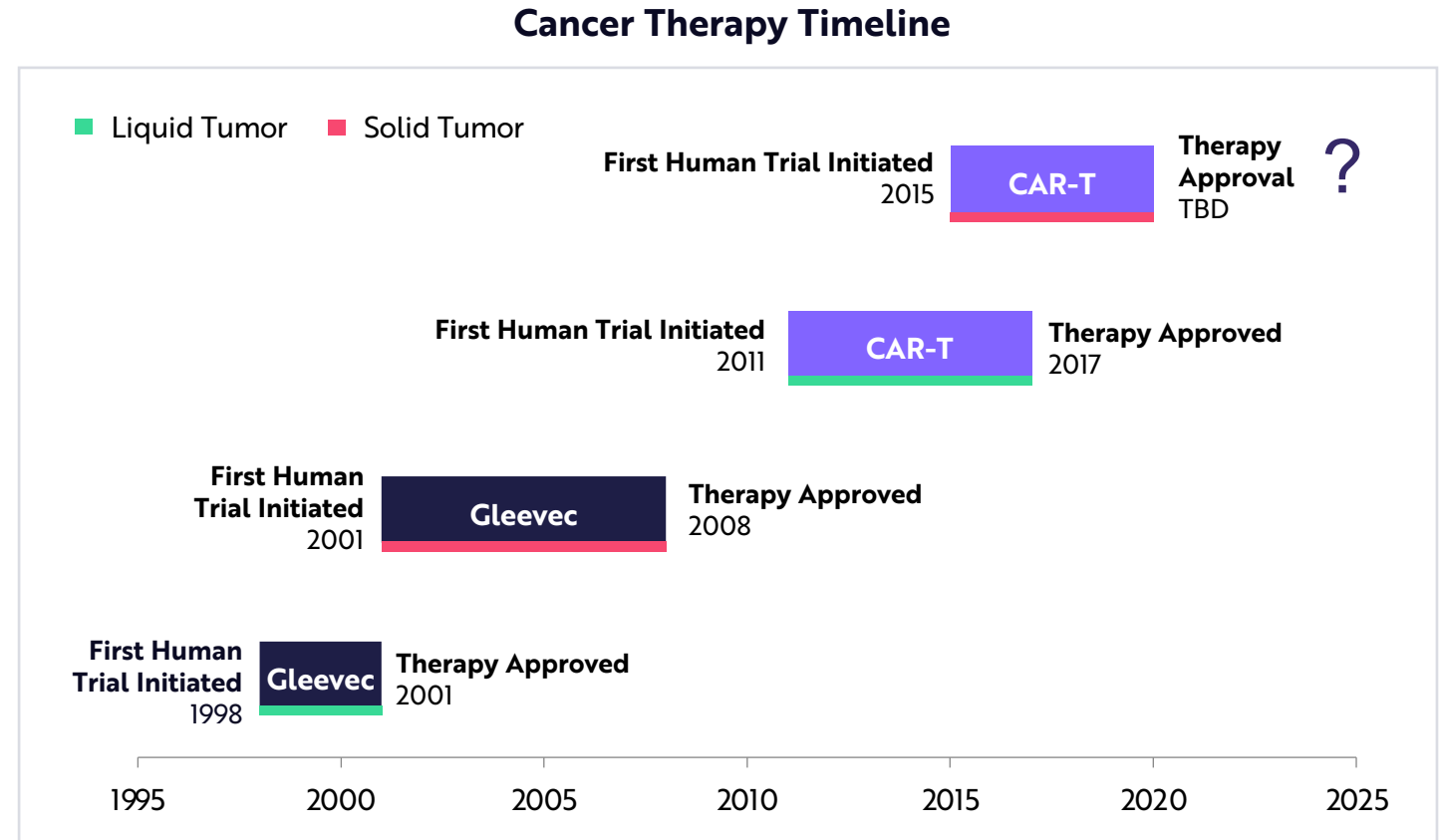
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[1] Autologous cell therapy is a novel therapeutic intervention that uses an individual's cells, which are cultured and expanded outside the body, and reintroduced into the donor. Allogeneic cell therapy relies on donor cells to treat many patients. [2] Ex vivo gene therapy means that the targeted cells are removed from the patient and gene therapy is administered to the cells in vitro before they are returned to the patient's body. In vivo gene therapy means that therapy is administered directly to the patient. The targeted cells remain in the body of the patient.



Cancer Therapies Are Shifting From Liquid To Solid Tumors

- Typically, cancer therapies are tested on liquid tumors first. Solid tumors, however, comprise 88%¹ of diagnosed cancers.
- The US Food and Drug Administration (FDA) approved Gleevec, an oral chemotherapy, after ten years of trials, seven years of which were in solid tumors. This timeline suggests that the FDA could approve the first CAR-T therapy for solid tumors in 2025.
- Because of artificial intelligence (AI), gene-editing, and next generation sequencing (NGS), failure rates and time-to-market should fall, accelerating approval rates.



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] Dunn, Barbara. "Cancer: Solving an Age-Old Problem." Nature News, Nature Publishing Group, 29 Feb. 2012, www.nature.com/articles/483S2a. Source: ARK Investment Management LLC, 2020 based on data sourced from: The US National Library of Medicine ClinicalTrials.gov; Nature News, Nature Publishing Group, www.nature.com/scitable/topicpage/gleevec-the-breakthrough-in-cancer-treatment-565/; A Brief History of CAR-T Cells: From Laboratory To The Bedside, Styczyński, Jan. "A brief history of CAR-T cells: from laboratory to the bedside." Acta Haematologica Polonica 51.1 (2020): 2-5. <https://doi.org/10.2478/ahp-2020-0002>; Imatinib In Chronic Myeloid Leukemia: An Overview; Sacha, Tomasz. "Imatinib In Chronic Myeloid Leukemia: an Overview." Mediterranean Journal of Hematology and Infectious Diseases, Università Cattolica Del Sacro Cuore, 2 Jan. 2014, www.ncbi.nlm.nih.gov/pmc/articles/PMC3894842/; Cancer Facts & Figures 2020, American Cancer Society, <https://www.cancer.org/research/cancer-facts-statistics/all-cancer-facts-figures/cancer-facts-figures-2020.html>.

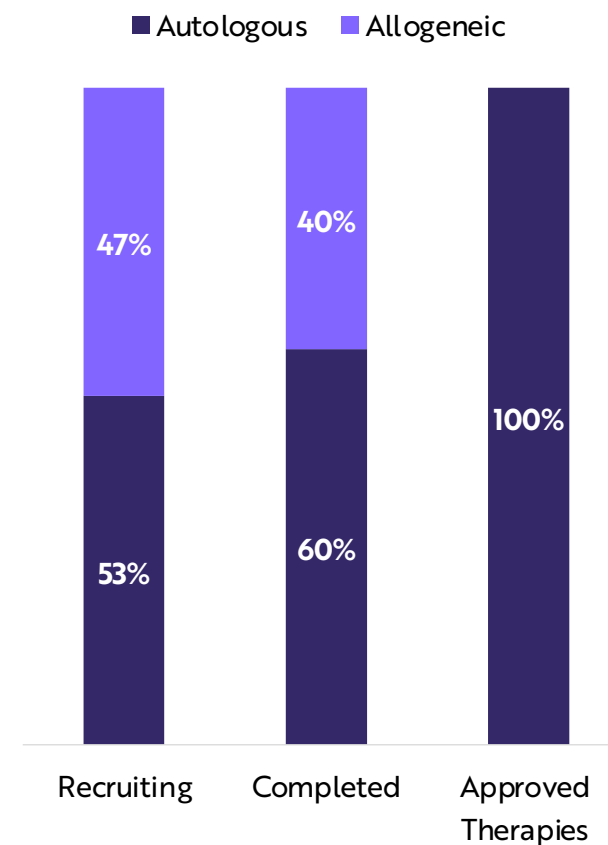


Oncology Trials Are Shifting From Autologous To Allogeneic Cell Therapies

- Allogeneic cell therapy involves cells 'off the shelf', or donated, whereas autologous cell therapy modifies the patient's own cells.
- One risk of allogeneic therapies is graft vs. host disease, causing a patient's immune system to attack the newly engineered cells. Despite this risk, allogeneic cells can facilitate therapies at earlier stages of cancer and reduce costs by an order of magnitude.
- Among gene therapy trials today, 40% of those completed and 47% in the patient recruitment phase were allogeneic. In ARK's view, the shift to allogeneic trials will continue.

	Autologous	Allogeneic
Cost, USD	\$100,000+	<\$10,000
Scalability		✓
No risk of cell rejection	✓	
Product consistency		✓
Ability to re-dose		✓
Expanded access to the sickest patients		✓

Autologous and Allogeneic Trials



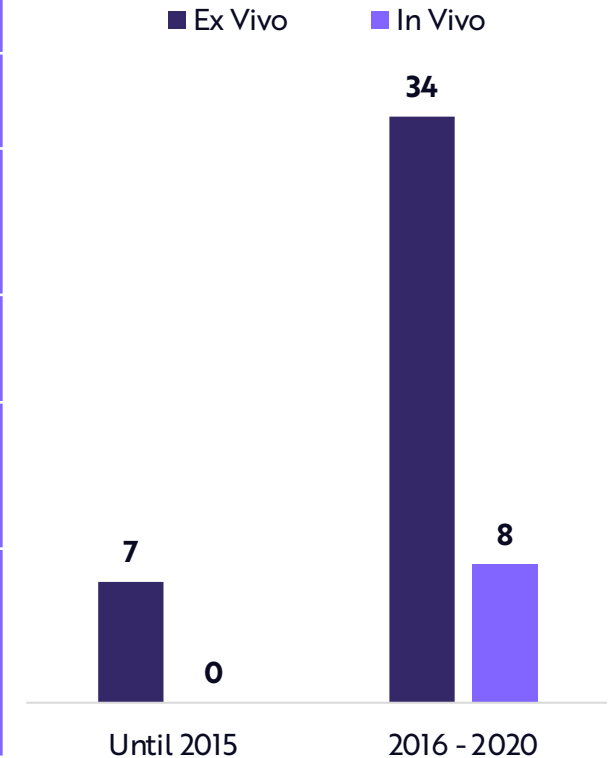


Gene Therapies Could Shift From Ex Vivo To In Vivo Editing

- 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.
- Unlike ex vivo, in vivo therapies cannot check edited cells before transduction. That said, in vivo gene therapy is more cost effective and easier to manufacture and scale. It also enables more access to the liver, eye, central nervous system (CNS), and muscles.

	Ex Vivo	In Vivo
Cost, USD	Higher	Lower
Scalability		✓
Ability to check edited cells before transduction	✓	
Product consistency		✓
Non-toxic conditioning regimens		✓
Expanded access to treatable diseases (i.e. muscle disorder)		✓

Clinical Trials with Active Genome Editors

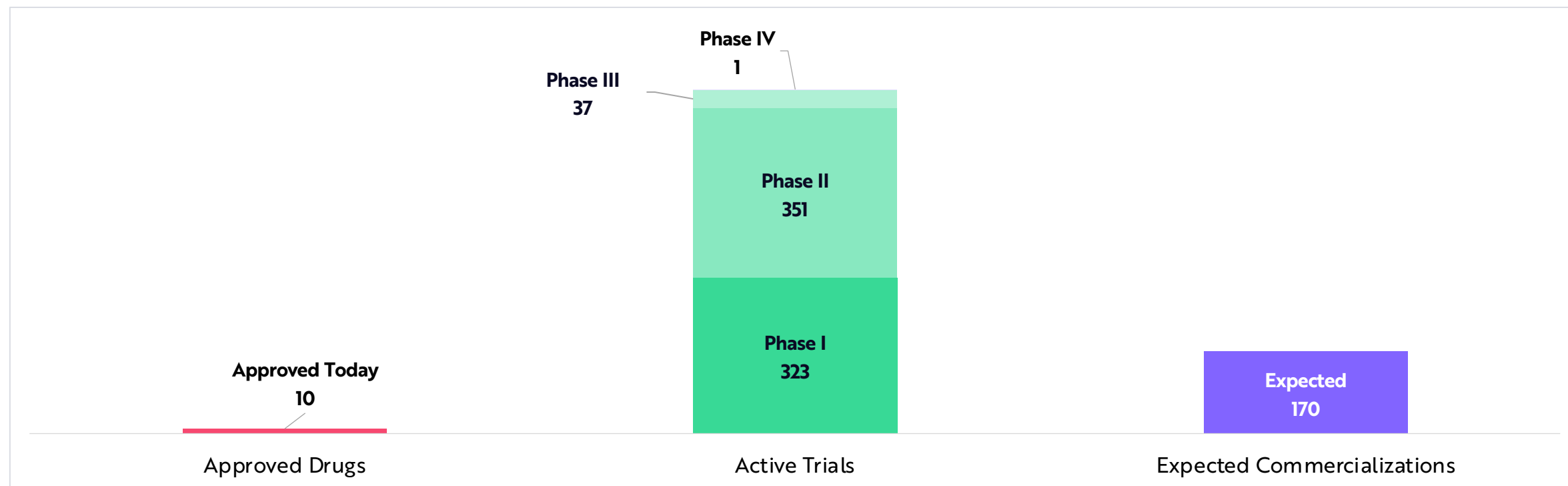




Gene Therapy And Editing Trials Have Increased Five-Fold Since 2010

To date, the FDA has approved only 10 gene therapies. As of year-end 2020, 712 active gene therapy clinical trials were underway, 238 of them initiated in 2020. Adjusting for the typical trial fail-rate, roughly 170 gene therapies are likely to be approved and commercialized¹ during the next decade.

Gene Therapies: Stages of Advancement



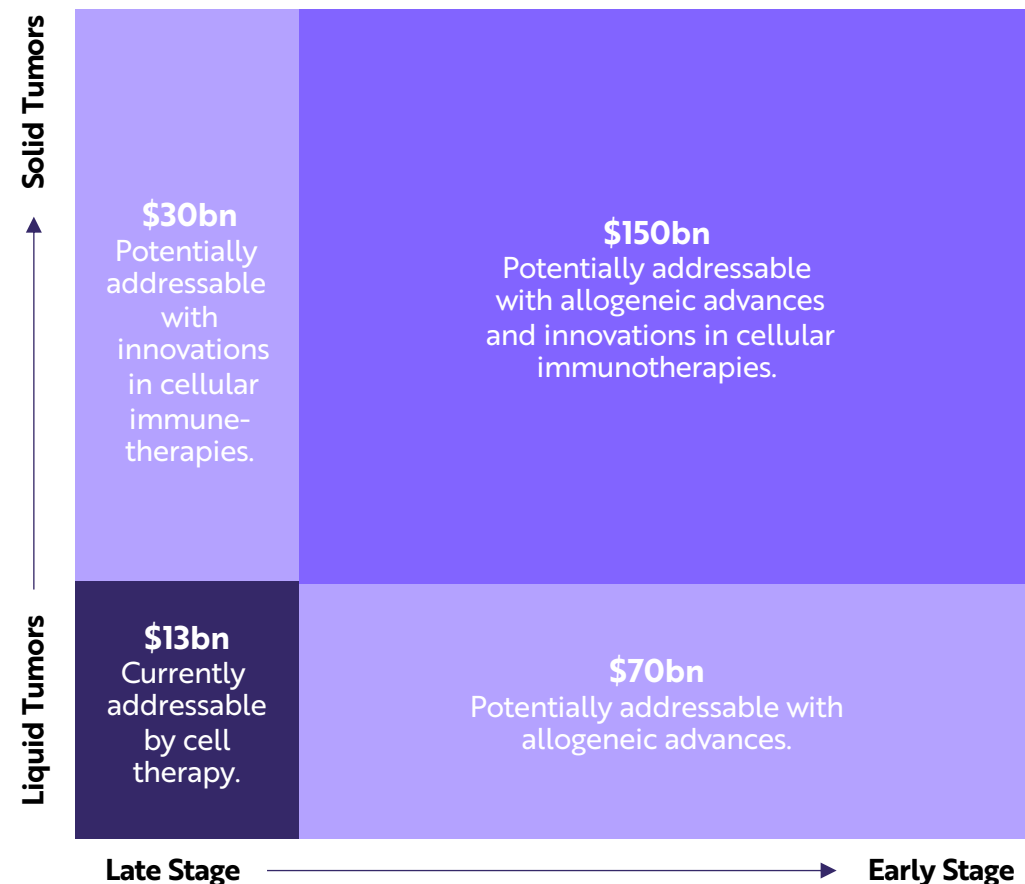


SIZING THE OPPORTUNITY

ARK Estimates That Allogeneic Cells And Cellular Immunotherapies Could Create \$250 Billion In Incremental Revenues.

- Innovation in cellular immunotherapies, including TILs, TCRs and CAR T cell therapies could increase the addressable market by nearly three-fold, adding \$30 billion to the current \$13 billion total addressable market (TAM).
- Allogeneic therapies enable easier applications in earlier stages of cancer, potentially increasing the TAM by \$70 billion.
- **The combination of cell therapy innovation and allogeneic cells could add an additional \$150 billion and increase the overall TAM for oncology gene therapy by roughly 20-fold to more than \$260 billion.**
- In vivo gene therapy could enable gene-editing to cure thousands of rare diseases over time.

Liquid and Solid Tumor Therapies: Total Addressable Market



Forecasts are inherently limited and cannot be relied upon.

Source: ARK Investment Management 2021, BCC Research Blood Cancer Therapeutics, <https://www.bccresearch.com/market-research/pharmaceuticals/blood-cancer-therapeutics-markets-report.html>,

Global Solid Tumor Therapeutics Market Size 2020, <https://www.marketgrowthreports.com/global-solid-tumor-therapeutics-market-16188814>

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