



# BIG IDEAS BY ARK INVEST 2020

January 14, 2020 | For Informational Purposes Only

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[www.ark-invest.com](http://www.ark-invest.com)



# Introduction to ARK's Big Ideas

ARK Invest aims to identify large-scale investment opportunities by focusing on public companies that are the leaders, enablers, and beneficiaries of disruptive innovation. While we believe innovation is the key to growth, the opportunities it creates often are missed or misunderstood by traditional investment managers who are more focused on sectors, indexes, short-term earnings, or 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 seem to be witnessing an acceleration in new technological breakthroughs.

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

**We hope you enjoy our “Big Ideas” for 2020.**





# ARK's Big Ideas 2020

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1. **Deep Learning** — From Vision to Language
2. **Streaming Media** — The Primary Technology Behind Content Distribution
3. **Electric Vehicles** — Faster Adoption Than Most Think
4. **Automation** — Increased Productivity and More Jobs
5. **3D Printing** — An Underestimated Technology
6. **Autonomous Ridehailing** — The Future of Transportation
7. **Aerial Drones** — A Cost Saver and Potential Life Saver
8. **Next Generation DNA Sequencing** — The Transformation of Oncology
9. **Biotech R&D Efficiency** — The Convergence of Technologies in Healthcare
10. **Digital Wallets** — The Transformation of Banking
11. **Bitcoin** — An Evolution of Monetary Systems

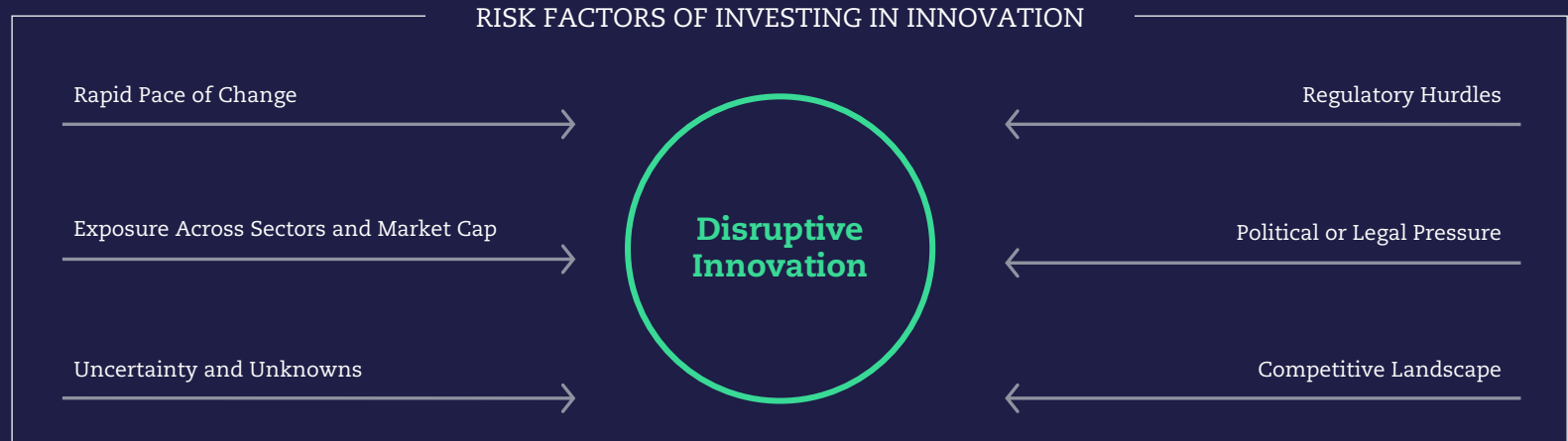




## Disclosure

# 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.



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

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



# Deep Learning

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Deep learning is powering the next generation of computing platforms. Thanks to deep learning, artificial intelligence (AI) systems can see, hear, and understand natural language at near human level accuracy.

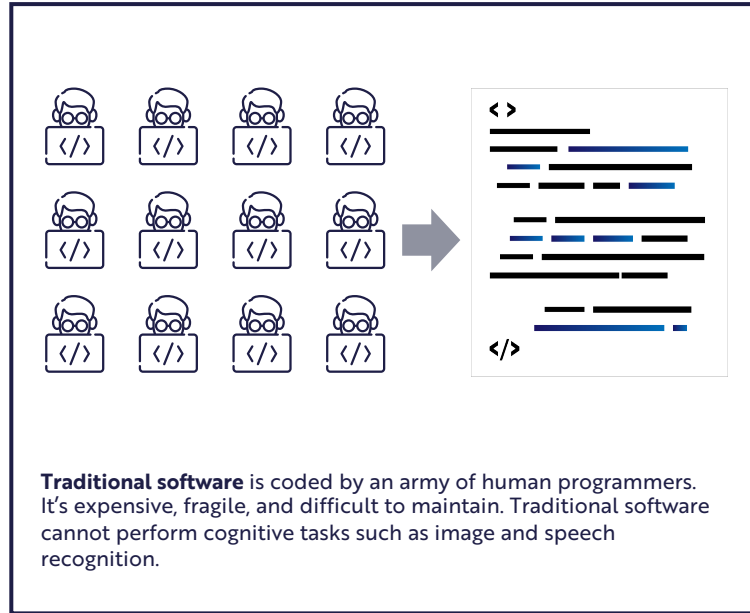
**ARK believes that deep learning will be more impactful than the Internet. The Internet created roughly \$10 trillion in global equity market capitalization in 20 years. We believe that deep learning will have 3x that impact, adding \$30 trillion to global equity markets over the next two decades.**



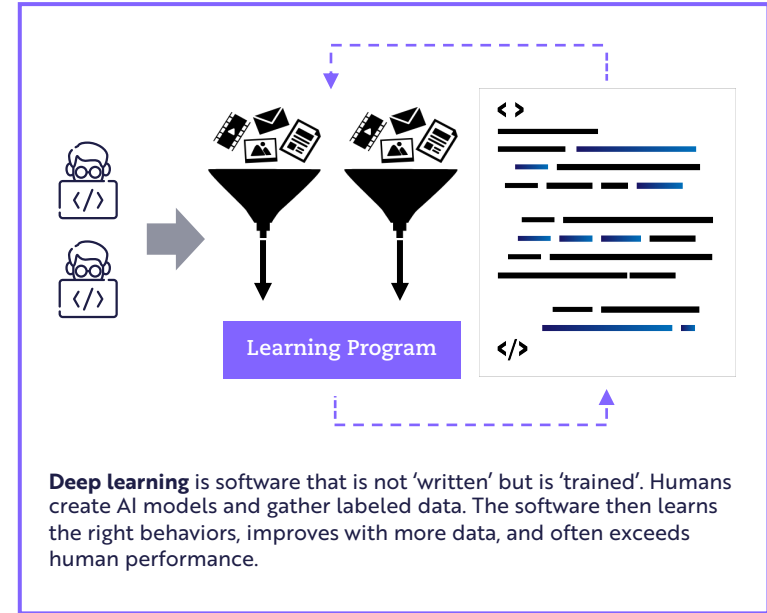


# Deep Learning Software Teaches Itself

## Traditional Software



## Deep Learning Software





# Deep Learning Is Powering the Next Generation of Computing Platforms

## Conversational Computers



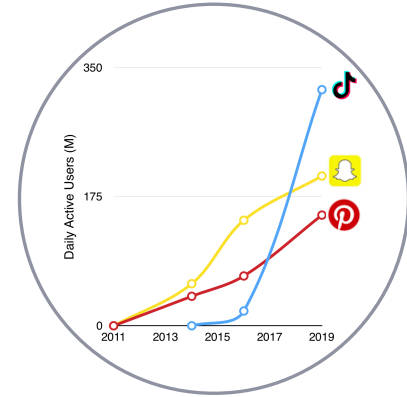
In 2019, smart speakers responded to 100 billion commands and questions, a number that increased 50% in just one year.<sup>1</sup>

## Self-Driving Cars



Waymo vehicles have traveled more than 20 million fully autonomous miles.<sup>2</sup>

## Consumer Apps



TikTok uses deep learning for video recommendations and is growing its user base 10x faster than is Snapchat.<sup>1</sup>

[1] Source: ARK Investment Management LLC, 2019; Based on company derived statistics.

[2] Kyle Wiggers, "Waymo's autonomous cars have driven 20 million miles on public roads", VentureBeat <https://arkinv.st/2N5fC4D>.

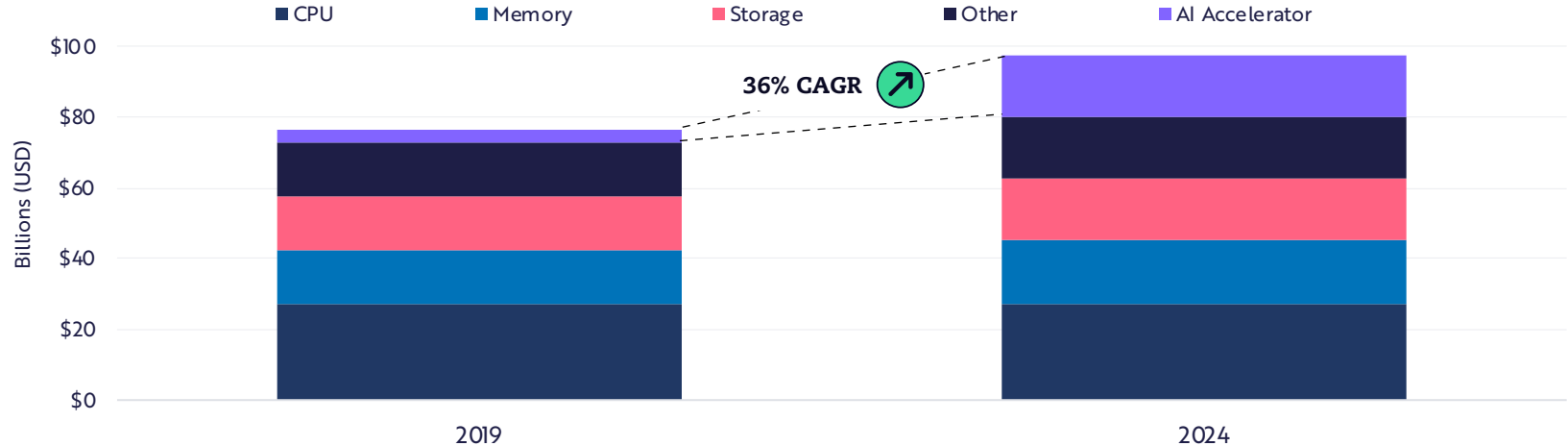
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# AI Software Should Create an \$18 Billion Market for AI Hardware

The slowdown in Moore's Law<sup>1</sup> means no more 'free' performance upgrades every two years. As a result, the server industry will have to invest in more computing hardware. AI accelerator chips, which optimize deep learning workloads, generated \$4 billion in revenue last year and should grow 36% at a compound annual growth rate (CAGR) to \$18 billion in 2024.

### Global Server Revenue by Component



[1] Moore's Law: Gordon Moore's prediction that the number of transistors on a chip would double every two years. Forecasts are inherently limited and cannot be relied upon. | Source: ARK Investment Management LLC, 2019; "Worldwide Server Market Revenue Declined 6.7% Year Over Year in the Third Quarter of 2019, According to IDC," IDC, 5 Dec. 2019, <https://arkinv.st/2ZSWcFh>. Assumes 15% OEM margin.



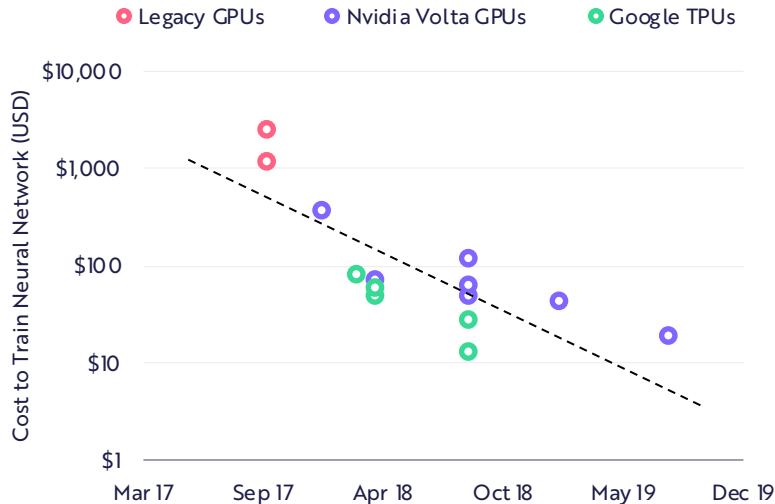


# Deep Learning Workloads Are Growing at 5x the Rate of Moore's Law

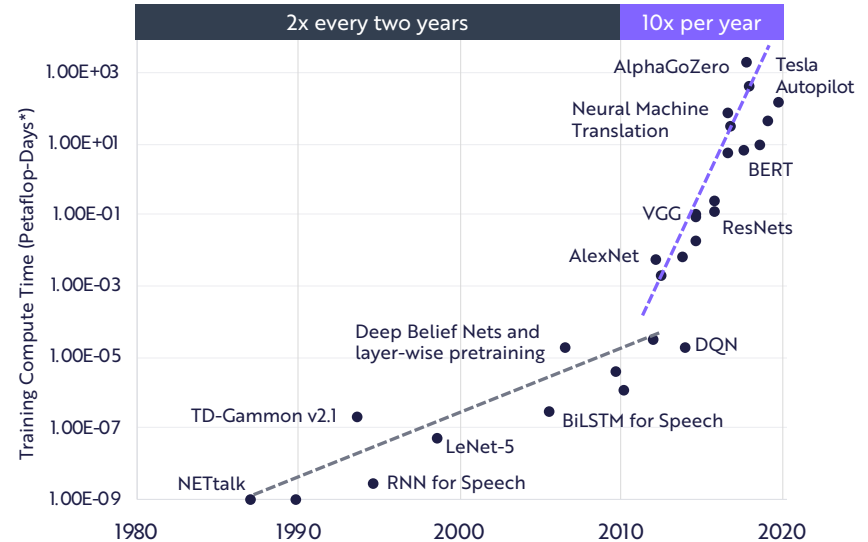
Hardware and software improvements reduced the cost to train neural networks by 100x in roughly two years. As a result, AI capabilities are multiplying as models are trained with 10x more computing power each year.

## Cost to Train a Neural Network For Image Recognition

(Using ResNet-50 Database)



## Two Eras of Compute Usage in Training AI Systems

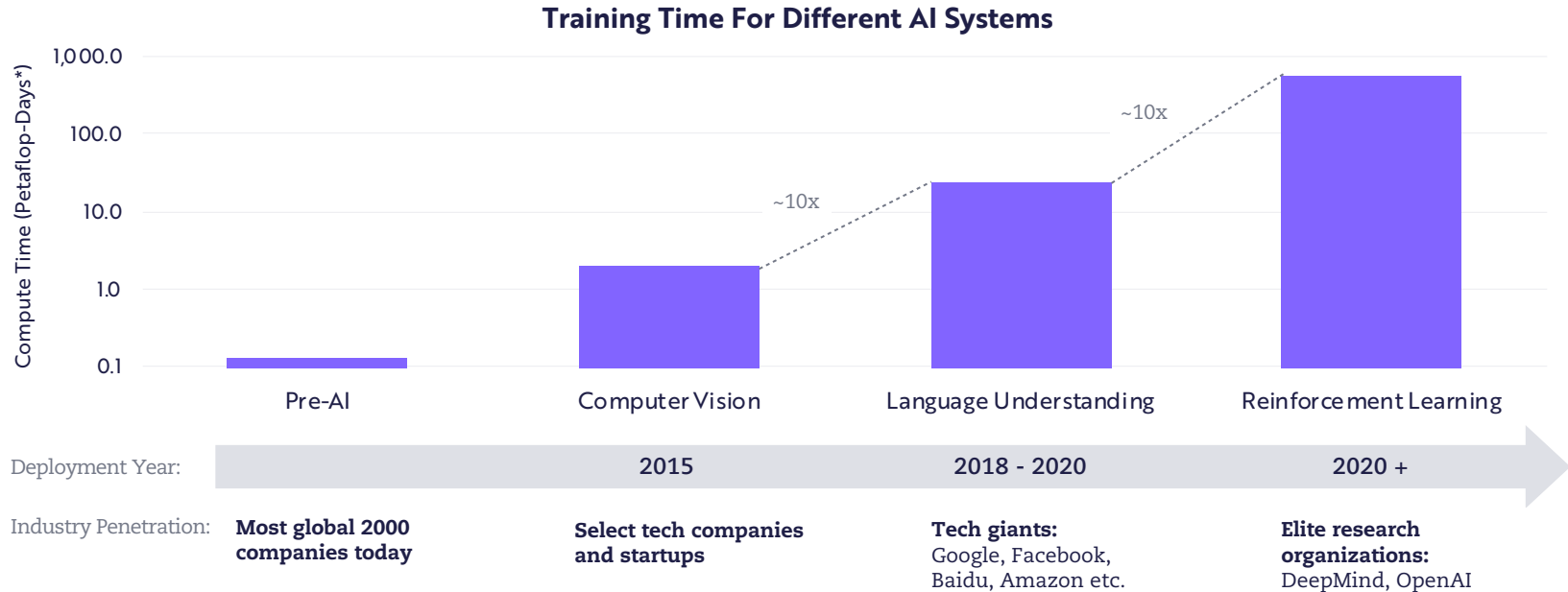


GPU: Graphics Processing Unit; TPU: Tensor Processing Unit | \*A "Petaflop-Day" refers to performing a quadrillion operations per second for a day. Source: ARK Investment Management LLC, 2019; Amodei, Dario. "AI and Compute." OpenAI, OpenAI, 12 Dec. 2019, <https://arxiv.st/2ZOH2Rr>; "DAWN Bench." Stanford DAWN Deep Learning Benchmark (DAWN Bench), <https://arxiv.st/2MUIYtO>. | This is not a recommendation in relation to any named securities and no warranty or guarantee is provided. Any references to particular securities are for illustrative purposes only.



# AI Is Expanding From Vision to Language

ARK believes that 2019 was the year of 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.



\*A "Petaflop-Day" is performing a quadrillion operations per second for a day. Forecasts are inherently limited and cannot be relied upon. | Source: ARK Investment Management LLC, 2019  
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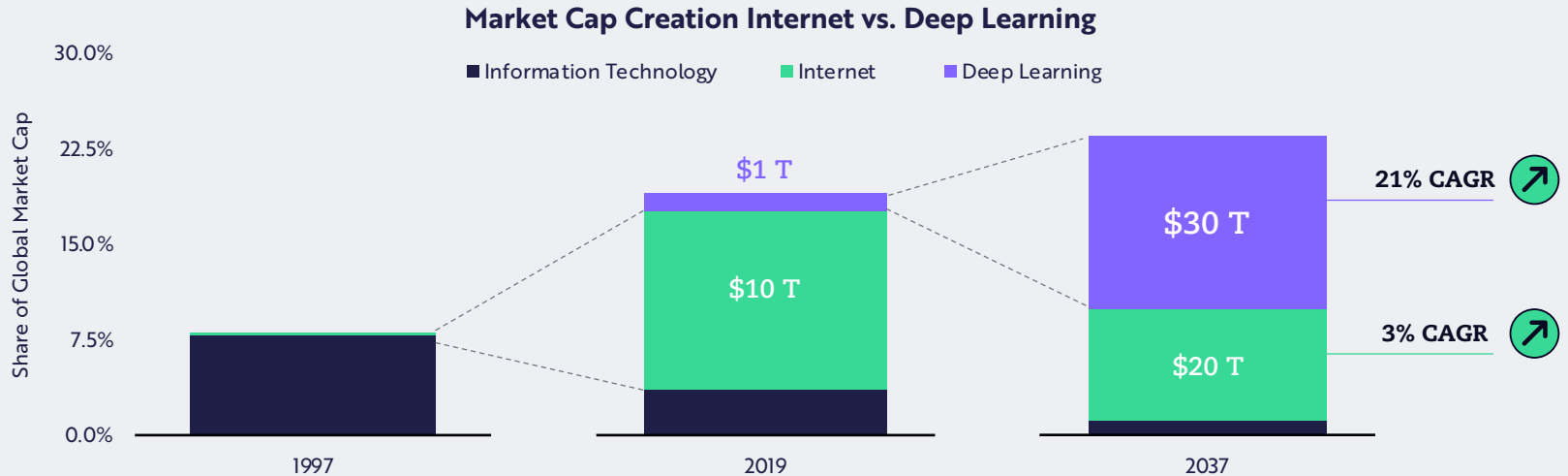


# Sizing the Opportunity



Deep learning could create more economic value than the Internet. Within two decades the Internet added roughly \$10 trillion to the global equity market cap. Since 2012, deep learning has created \$1 trillion in market capitalization.

**ARK believes it will add \$30 trillion by 2037.**



Forecasts are inherently limited and cannot be relied upon.  
Source: ARK Investment Management LLC, 2019



# Streaming Media

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Streaming technology is delivering more and more content over the Internet. Now consumers have instant access to massive video, audio and game libraries. ARK believes streaming could become the primary technology behind content distribution, reshaping viewing habits.

**According to our research, streaming revenue should more than quadruple during the next five years, from \$86 billion today to \$390 billion in 2024.**





# Historically Companies Sold Either Content or Distribution – Now They Are Vertically Integrating Through Both

1980–2010

Content



Distribution



2010+

Content & Distribution

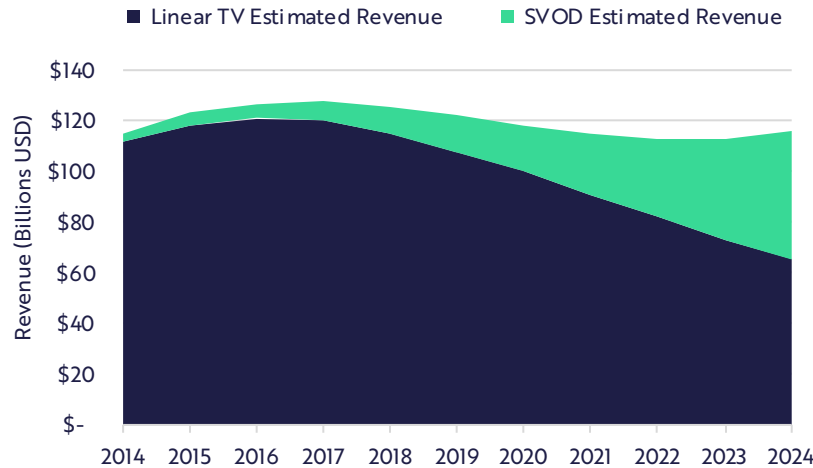




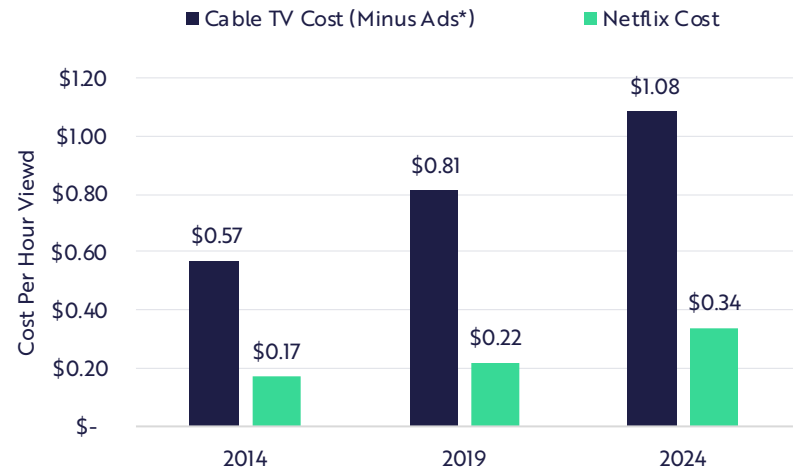
# Subscription Video On Demand (SVOD) Is Taking Over Linear TV

SVOD is a relatively inexpensive source of premium content. Per hour watched, Netflix costs consumers nearly 75% less than cable. Thanks to compelling costs, Americans watch 3.4 streaming services on average.

### Linear TV vs. SVOD: US Market Share



### Cable TV vs. Netflix Subscription: US Cost Per Hour Viewed

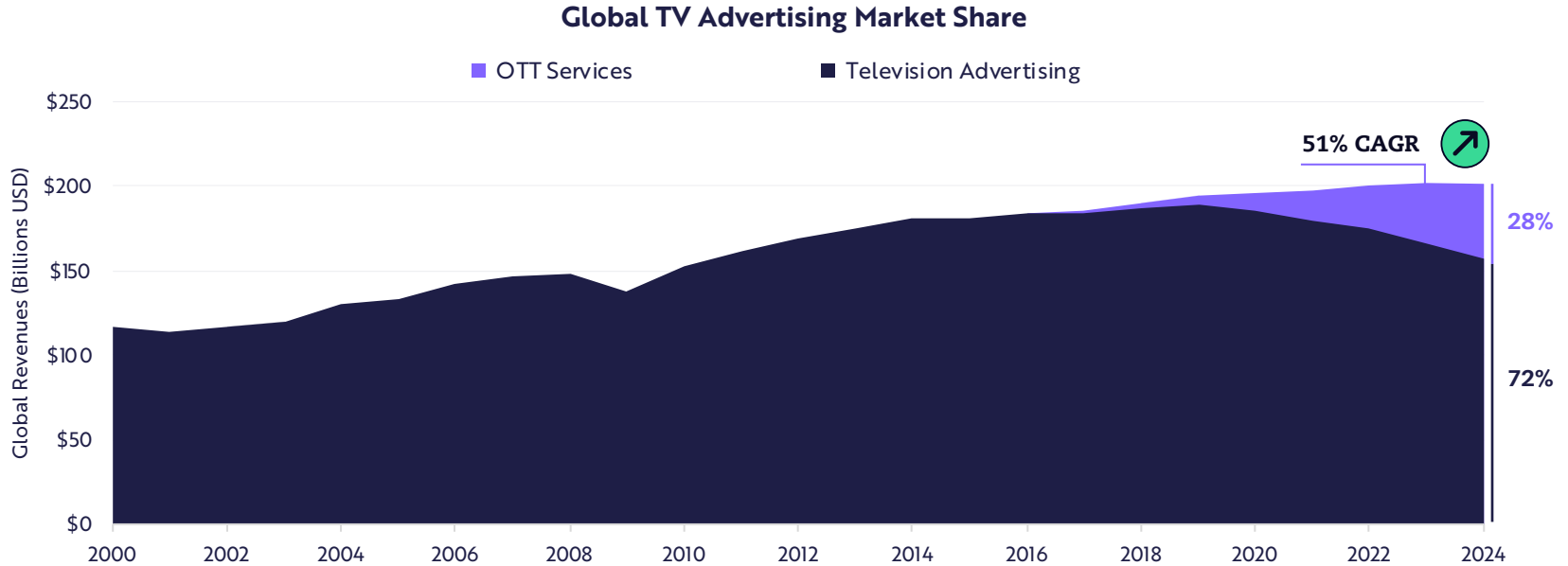


\*Minus Ads: In our cost per hour estimate for cable we excluded the amount of time spent watching advertisements. Forecasts are inherently limited and cannot be relied upon. | Source: ARK Investment Management LLC, 2019; Fitzgerald, Toni, "How Many Streaming Video Services Does The Average Person Subscribe To?" Forbes, Forbes Magazine, 29 Mar. 2019, <https://arkinv.st/2ZMohxS>; "The Cross Platform Report." Nielsen, Oct. 2011, <https://arkinv.st/39sMoGB>; "Cable Operators' Shift to Profit Mode Accelerates Cord-Cutting." EMarketer, <https://arkinv.st/35UbFo>; Sutton, Kelsey. "Nearly 25% of U.S. Households Will Be Cord-Cutters by 2022, According to EMarketer." Adweek, Adweek, 6 Aug. 2019, <https://arkinv.st/2ZM6hnw>.



# Linear TV Advertising Is Approaching a Cliff

Ad-supported over-the-top (OTT) streaming channels should gain significant market share during the next few years. According to ARK's research, OTT ad revenues could increase more than 7x during the next five years, from nearly \$6 billion in 2019 to roughly \$44 billion in 2024.



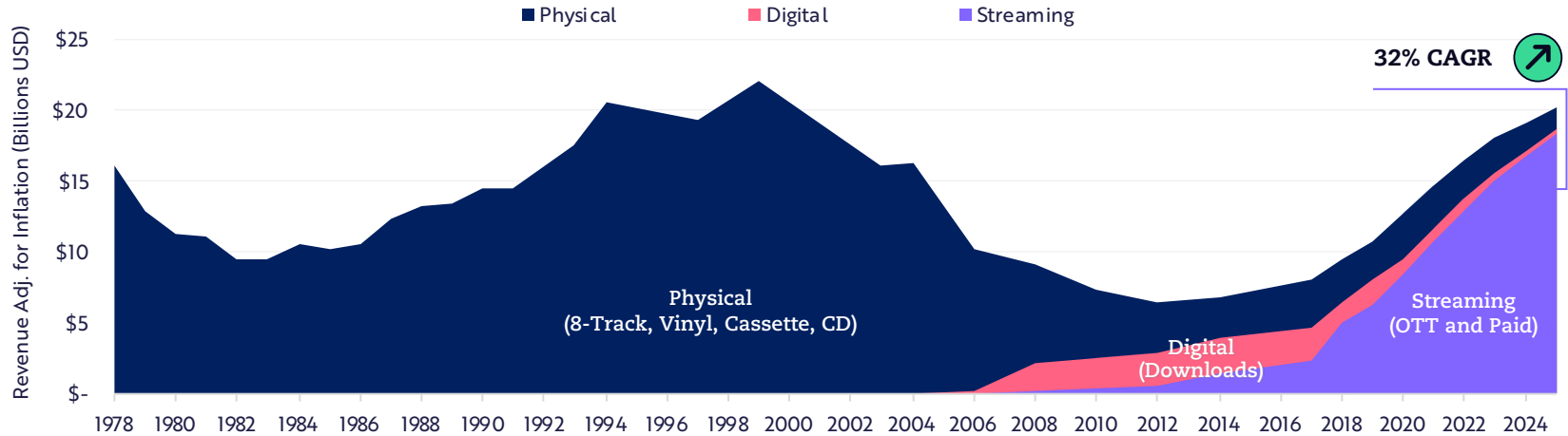
Forecasts are inherently limited and cannot be relied upon.  
Source: ARK Investment Management LLC, 2019; "Booming Internet Ads Power Faster Global Adspend Growth." Zenith, 21 Mar. 2019, <https://arkin.vt/36juELP>.



# Music Streaming Services Are Reviving the Industry, and Reshaping It

Thanks to streaming, the music industry is recovering from more than a decade of declining revenues. According to ARK's research, music streaming revenue could quadruple in the US, from \$13 billion in 2019 to \$52 billion in 2024.

### US Music Industry Revenue Forecast During the Next Five Years



Forecasts are inherently limited and cannot be relied upon.  
Source: ARK Investment Management LLC, 2019; "2018 RIAA Music Industry Revenue Statistics: RIAA." RIAA, <https://arkin.vt/39BdB9S>.

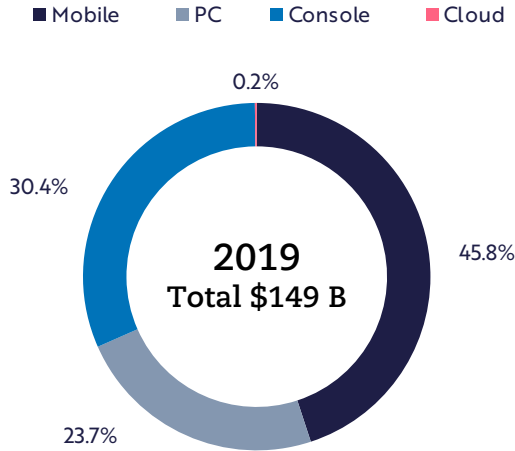




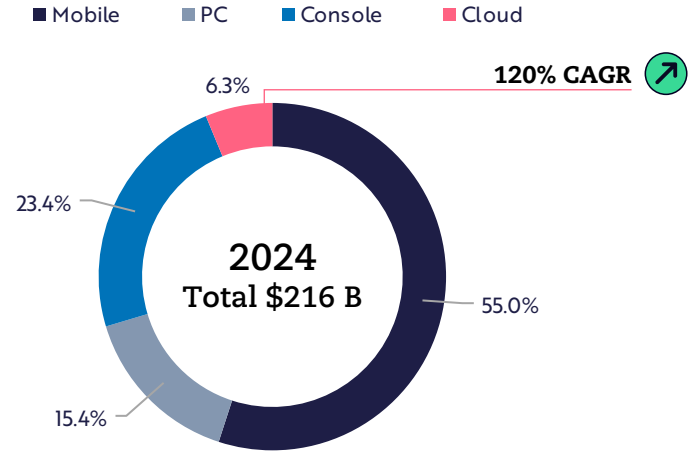
# Cloud Gaming Is Poised For Explosive Growth

Cloud gaming<sup>1</sup> is likely to take share from console- and PC-gaming, growing from nearly \$263 million in 2019 to \$13.5 billion, or from 0.2% to 6.3% share during the next five years. Among the reasons for this share shift are instant access to games, dynamic back end support, and compatibility with any device.

### 2019 Estimated Global Game Market Share



### 2024 Forecast of Global Game Market Share

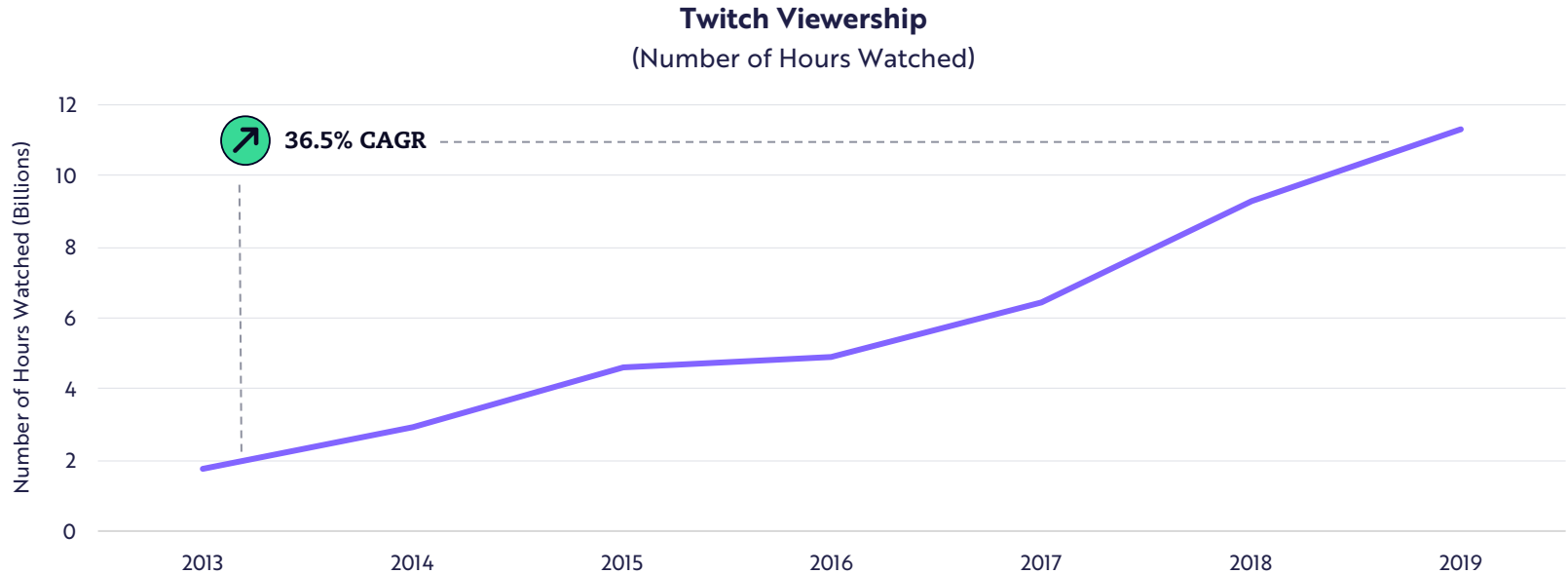


[1] We consider cloud gaming to be subscription-based services that offer instant access to gaming content libraries. Forecasts are inherently limited and cannot be relied upon. Source: ARK Investment Management LLC, 2019; "Newzoo's Global Games Market Report." Newzoo, <https://arkinv.st/37su2nc>.



# Live Streaming Is Taking Off in New Verticals

Typically in the form of video, live streaming<sup>1</sup> is gaining popularity globally, with a particularly strong impact on Esports. Amazon's Twitch is the 58th most popular site in the world, streaming more than 11 billion hours in 2019 alone, according to ARK's estimates.



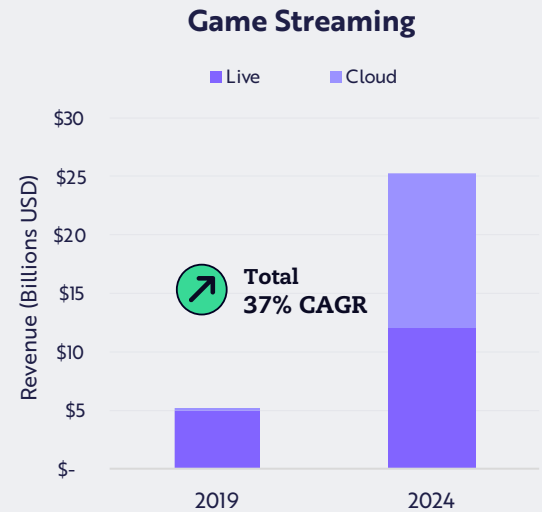
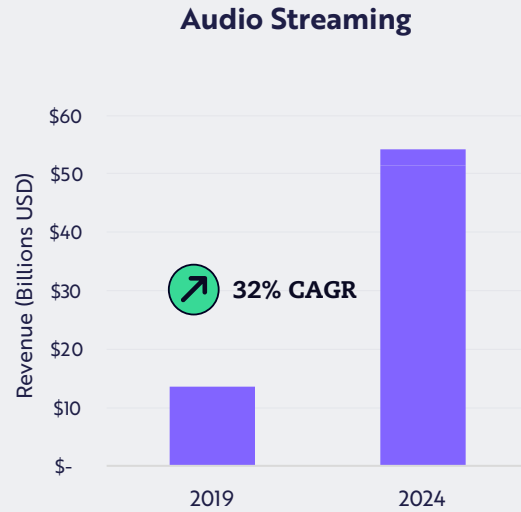
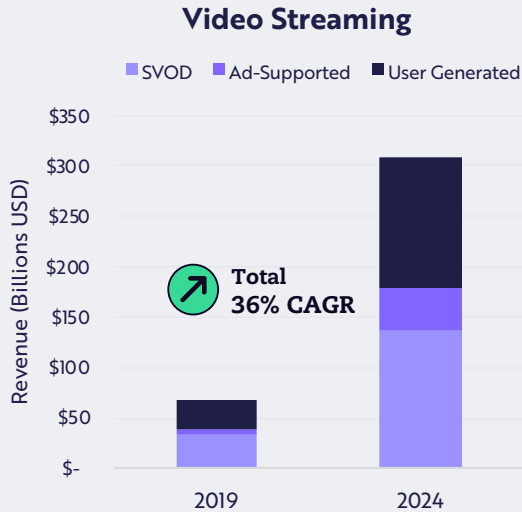
[1] We consider live streaming to be web-based platforms that allow users to stream their game-play to a broader audience. Source: ARK Investment Management LLC, 2019 based on data sourced from twitchtracker.com ; "Livestreaming - A \$5 Billion Global Phenomenon." Roundhill Investments, <https://arkinv.st/2FcVUiX>. This is not a recommendation in relation to any named securities and no warranty or guarantee is provided. Any references to particular securities are for illustrative purposes only.



# Sizing the Opportunity



Total streaming revenue could grow 35% at an annual rate, from an estimated \$86 billion in 2019 to roughly **\$390 billion in 2024.**



Forecasts are inherently limited and cannot be relied upon. | Source: ARK Investment Management LLC, 2019 based on data sourced from zenithmedia.com; "Newzoo's Global Games Market Report." Newzoo, <https://arkinv.st/37su2nc>; "2018 RIAA Music Industry Revenue Statistics: RIAA." RIAA, <https://arkinv.st/39BdB9S>; "Livestreaming - A \$5 Billion Global Phenomenon." Roundhill Investments, <https://arkinv.st/2FcVUix>.



# Electric Vehicles (EVs)

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Four years ago, the Energy Industry Administration (EIA) and other forecasting agencies estimated that EV sales would total a few hundred thousand units in the early 2020s. After EV sales hit 1.45 million units in 2018 and an estimated 2 million in 2019, the same agencies now forecast roughly 6.5 million in 2024.

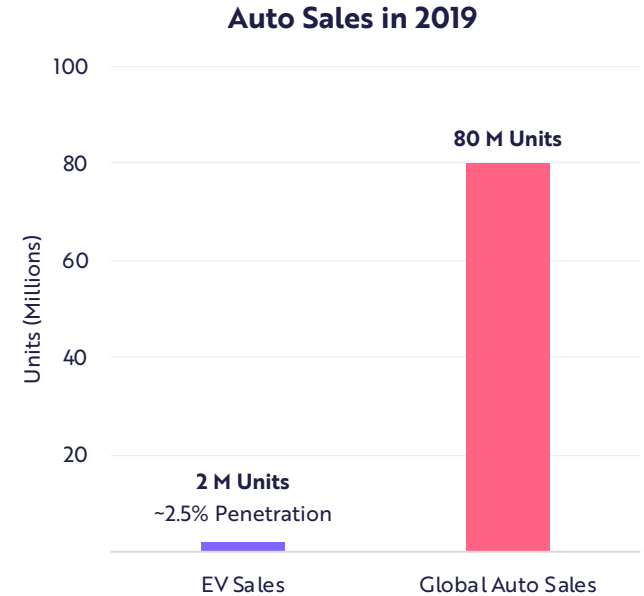
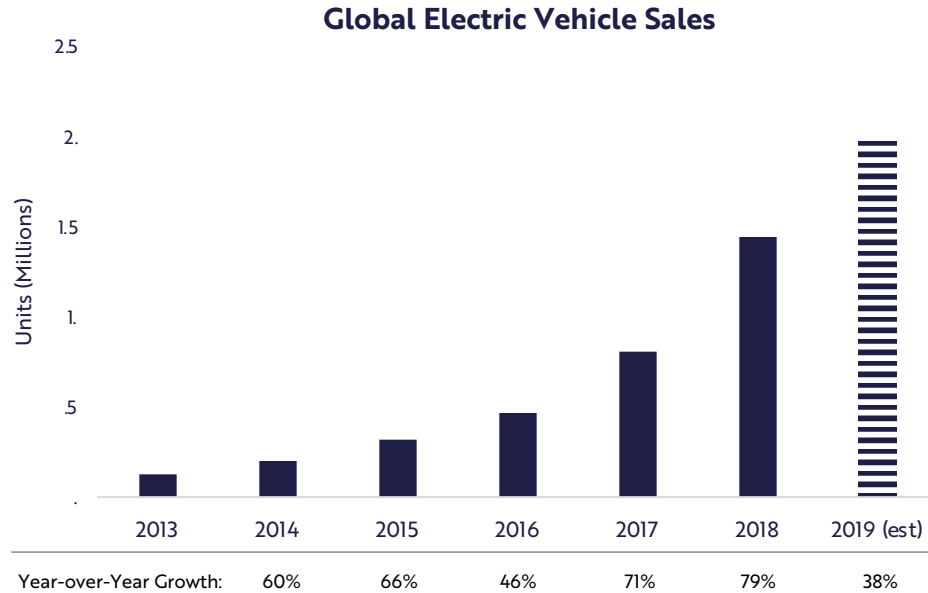
ARK's thesis for the evolution of the market differs dramatically. **Based on Wright's Law, we forecast EV sales will be 37 million units, six-times higher than the forecasting agencies' consensus estimate for 2024.**





# EV Sales Are Increasing As Gas-Powered Auto Sales Shrink

Despite an estimated 3.1 million drop in total auto sales worldwide,<sup>1</sup> EV sales are expected to grow significantly during the next five years. EV sales growth could be lumpy as factories build to scale but should be robust over time as EV adoption gains traction.



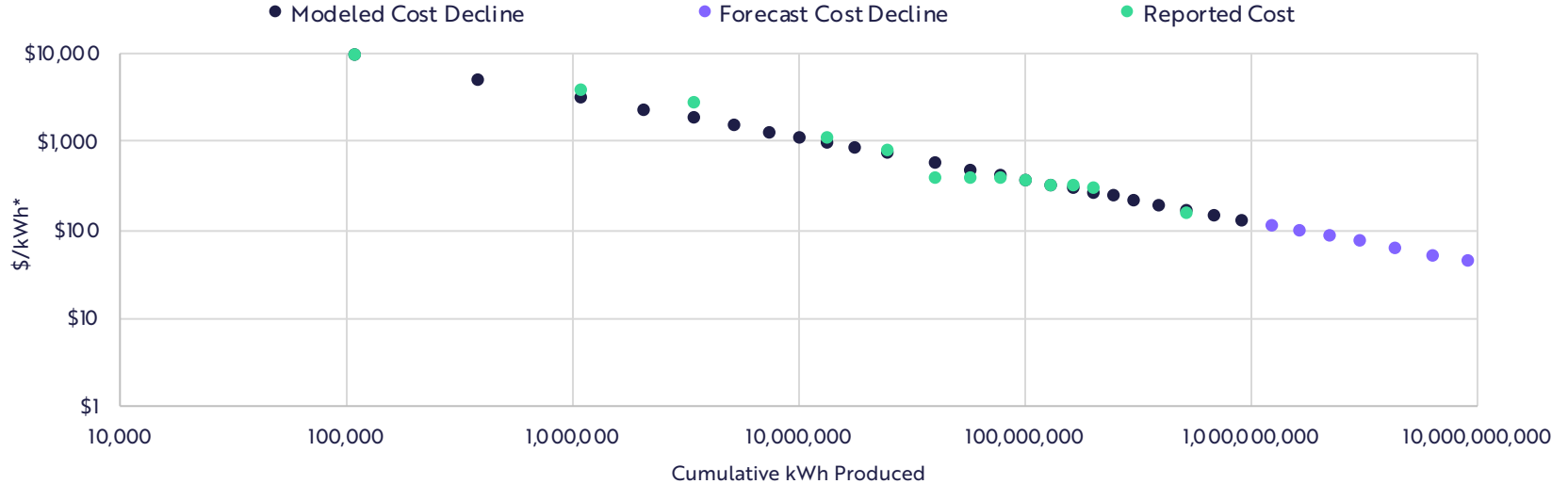
[1] Raimonde, Olivia. "Global Car Sales Expected to Slide by 3.1 Million This Year in Steepest Drop since Great Recession." CNBC, CNBC, 25 Nov. 2019, <https://arkinv.st/35bYEHHL>. Forecasts are inherently limited and cannot be relied upon. | Source: ARK Investment Management LLC, 2019; Based on data sourced from: EV-volumes.com.



# Wright's Law Forecasts the Decline in Battery Costs

According to Wright's Law, for every cumulative doubling of units produced, battery cell costs will fall by 18%. These cost declines are critical to reaching price parity with gas-powered vehicles, as the largest cost component of an EV is its battery.

### ARK's Lithium-Ion Battery Cost Decline Model



\*kWh: Kilowatt hour

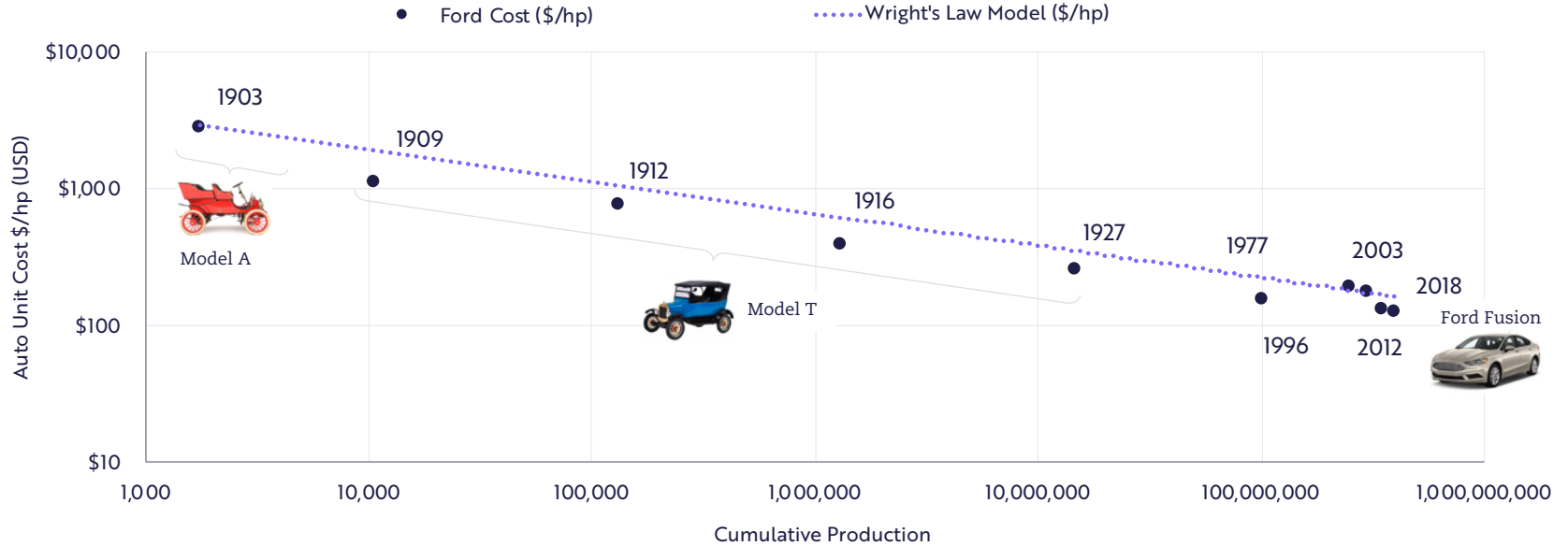
Forecasts are inherently limited and cannot be relied upon.

Source: ARK Investment Management LLC, 2019; Based on data sourced from: Avicenne Energy, International Energy Agency (IEA), and Bloomberg New Energy Finance.



# Wright's Law Has Forecast Auto Costs Accurately For More Than 100 Years

## Wright's Law Applied to Auto Costs Over the History of the Industry (Adjusted for Inflation)



Source: ARK Investment Management LLC, 2019  
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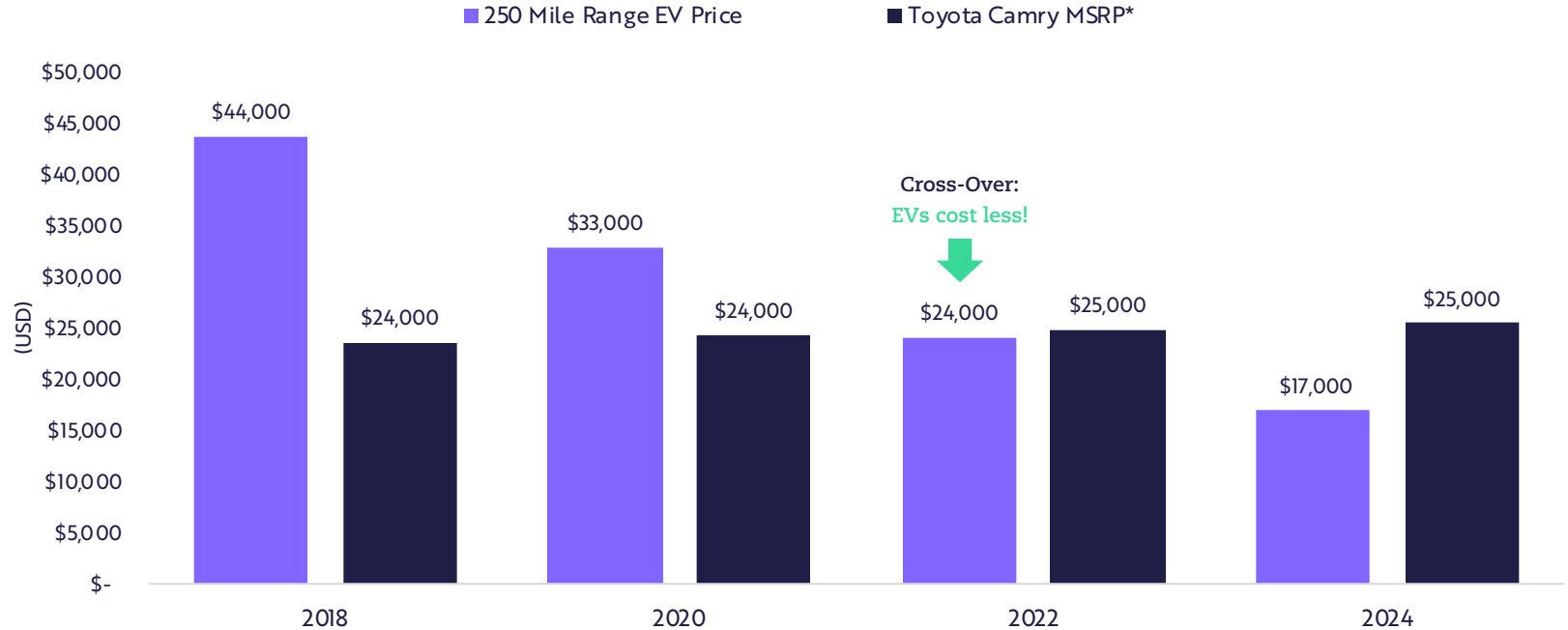


# EVs Are Nearing Price Parity With Gas-Powered Cars

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## Electric Vehicle Price Parity



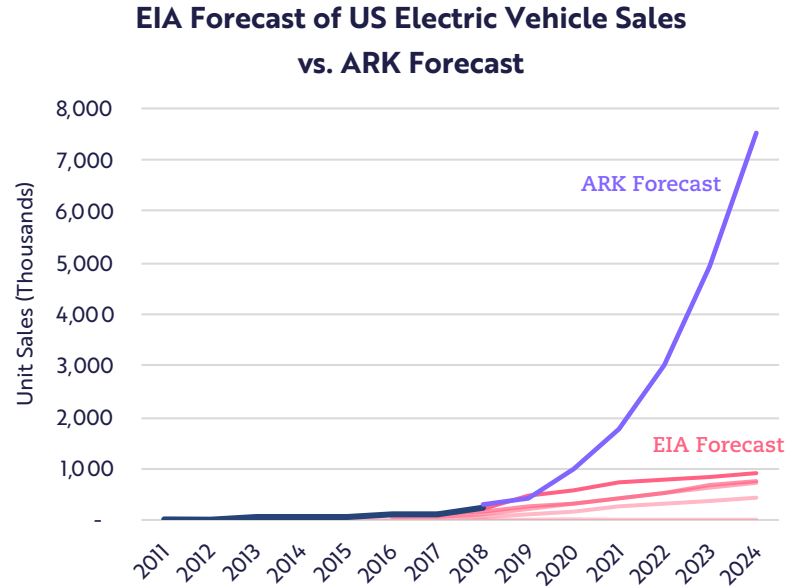
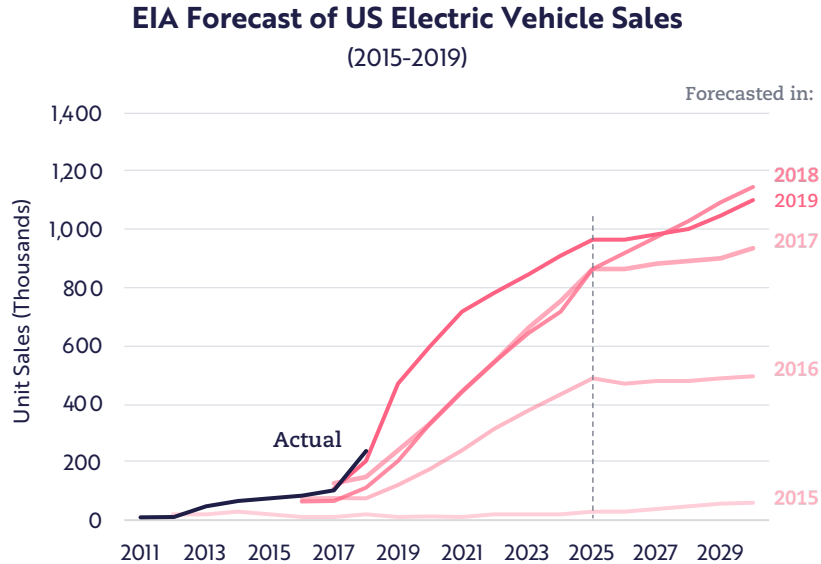
\*MSRP: Manufacturer Suggested Retail Price  
Forecasts are inherently limited and cannot be relied upon. | Source: ARK Investment Management LLC, 2019  
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# The EIA Has Revised Up Its EV Forecasts Consistently

The Energy Industry Administration (EIA) has increased its US forecasts for EV sales significantly but consistently tapers growth beyond 2025, ignoring traditional adoption curves.



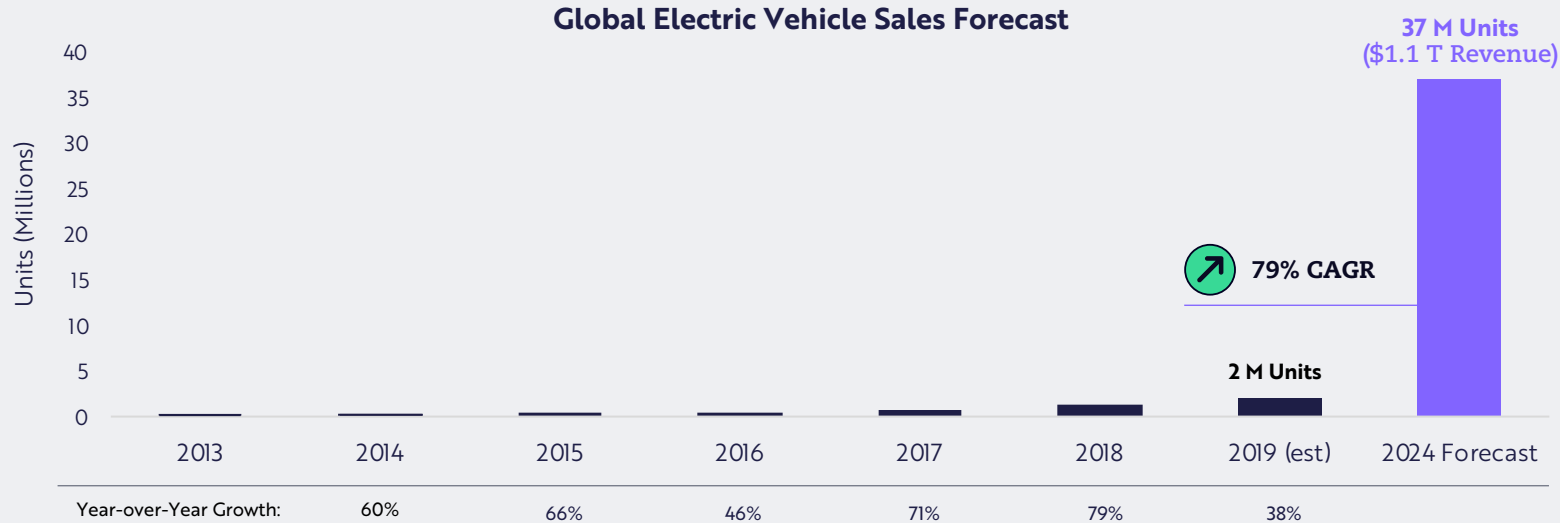
Forecasts are inherently limited and cannot be relied upon.  
Source: ARK Investment Management LLC, 2019; "U.S. Energy Information Administration - EIA - Independent Statistics and Analysis." EIA, <https://arkinv.st/2F5SY7R>.



# Sizing the Opportunity



The biggest risk to ARK's forecast is whether or not traditional automakers will be able to scale EV production. If they do, then global EV sales could hit **37 million units in 2024**.



Forecasts are inherently limited and cannot be relied upon. Source: ARK Investment Management LLC, 2019; Based on data sourced from: EV-volumes.com.



# Automation

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Automation encompasses industrial robots, service robots, and automation systems. While many observers fear that automation will destroy jobs, ARK believes it will empower humans, increasing both productivity and wage growth.

**According to ARK's research, automation will add \$800 billion to US Gross Domestic Product (GDP) by 2024, and potentially \$12 trillion by 2035.**





# Automation Encompasses Industrial Robots, Service Robots, and Automation Systems Powered by Neural Networks

## Industrial Robots



Manufacturing

## Service Robots



Logistics, Vacuums, Delivery Robots, Nurse Assistants

## Automation Systems



Restaurants, Production Lines

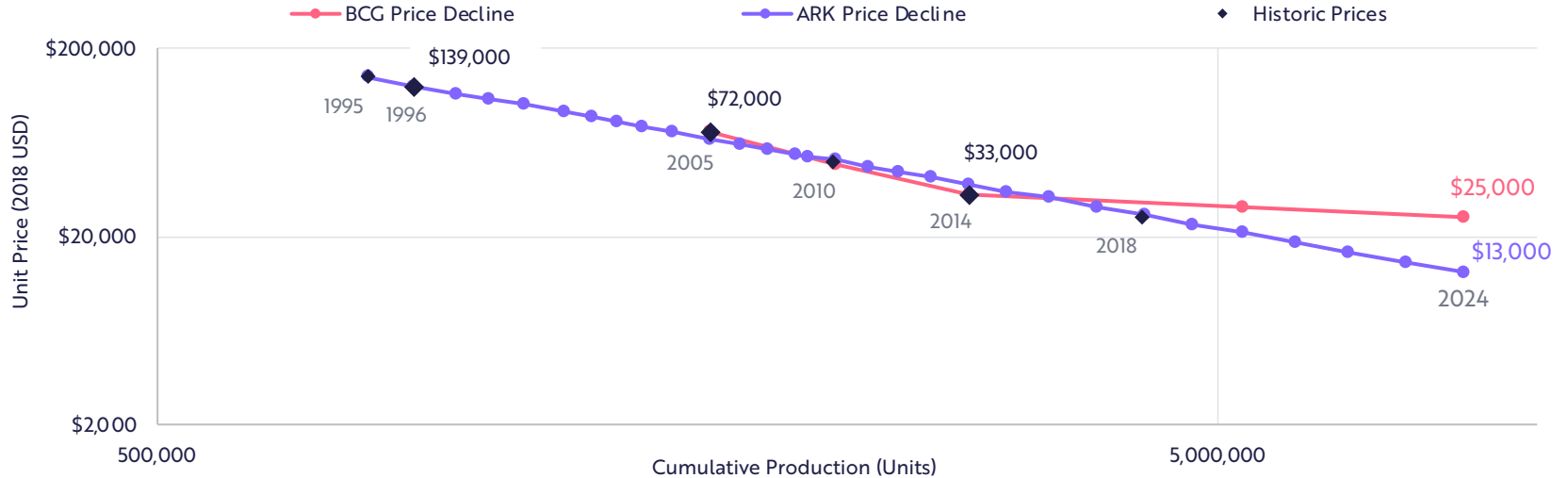




# Industrial Robot Prices Are Declining

Based on Wright's Law, ARK estimates a more rapid cost decline in industrial robot prices during the next five years compared to a forecast by the Boston Consulting Group (BCG).

### ARK's Industrial Robot Price Decline Model



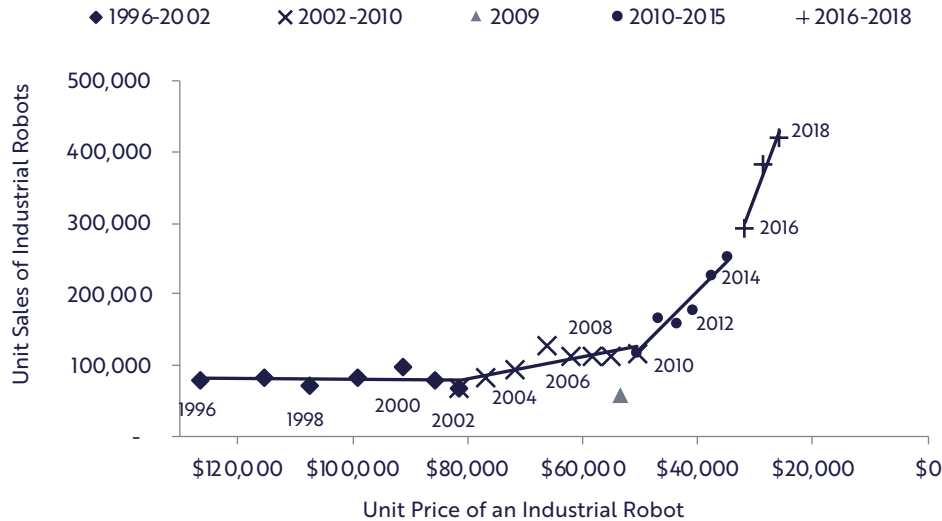
Forecasts are inherently limited and cannot be relied upon. | Source: ARK Investment Management LLC, 2019, "World Robotics." IFR International Federation of Robotics, <https://arkinv.st/36dFXVJ>; Boston Consulting Group (BCG) "How Robots Will Redefine Competitiveness." 23 Sept. 2015, <https://arkinv.st/2SDew3B>.



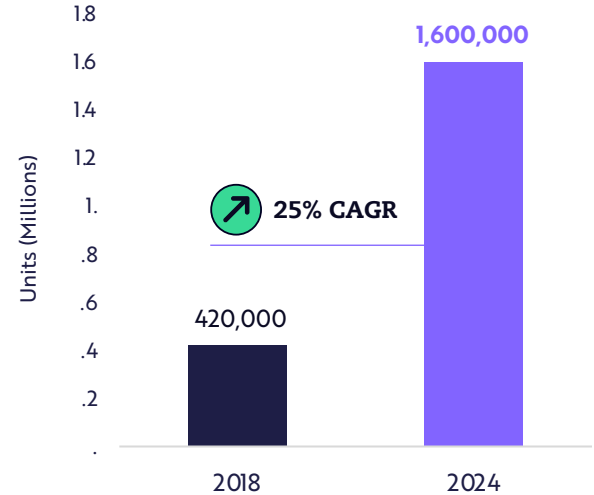
# Robot Demand Has Responded to Lower Prices

While they flattened in 2019 in response to the US-China trade conflict and a slowdown in the global auto industry, ARK expects robot sales to quadruple during the next five years, from roughly 420,000 in 2018 to 1.6 million in 2024.

### Industrial Robot Price Elasticity of Demand



### ARK Industrial Robot Forecast



Forecasts are inherently limited and cannot be relied upon. Source: ARK Investment Management LLC, 2019; "World Robotics." IFR International Federation of Robotics, <https://arkinvt.st/36dFXVJ>.

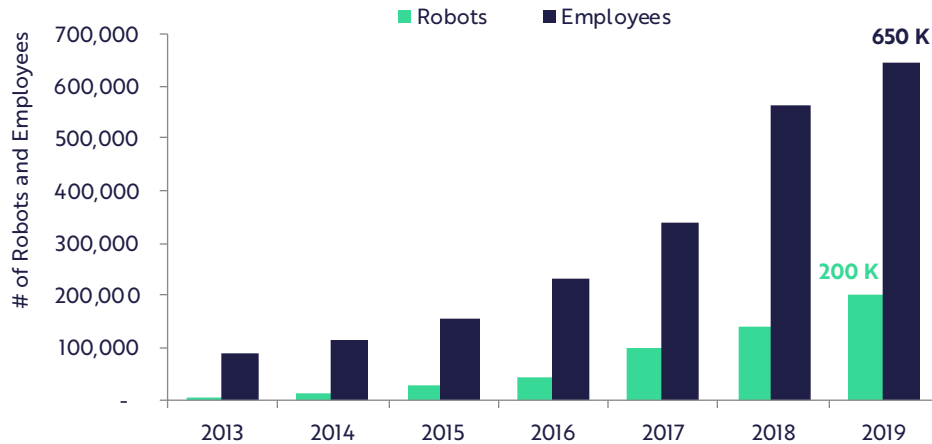


# Service Robots Are Penetrating the Logistics Space

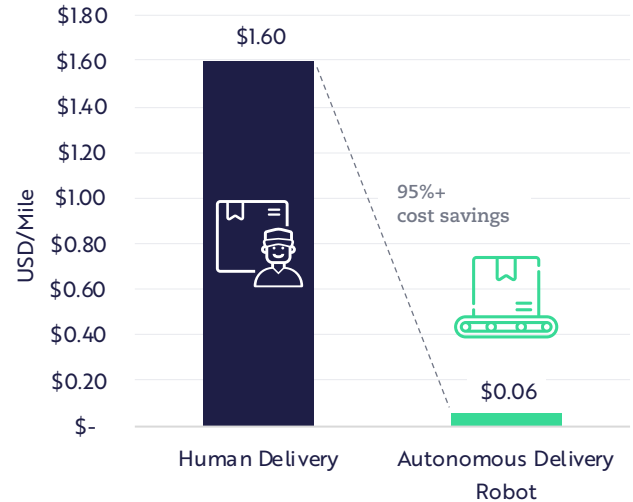
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Since deploying its first robot in 2012, Amazon has ramped them to roughly 200,000 units in its fulfillment centers while increasing total employment 7x. Based on their superior economics, robots are likely to dominate the food delivery space as well.

### Number of Robots in Amazon's Fulfillment Centers Compared to Total Employment at Amazon



### Cost of Delivery



Source (Left Chart): ARK Investment Management LLC, 2019; Amazon SEC Filings, Amazon, <https://arkinv.st/2ZCRyuT>.

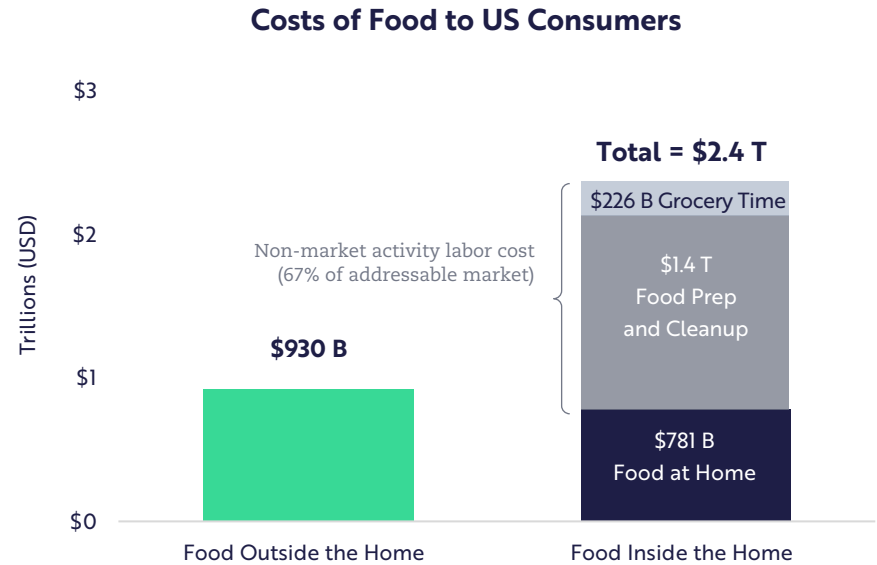
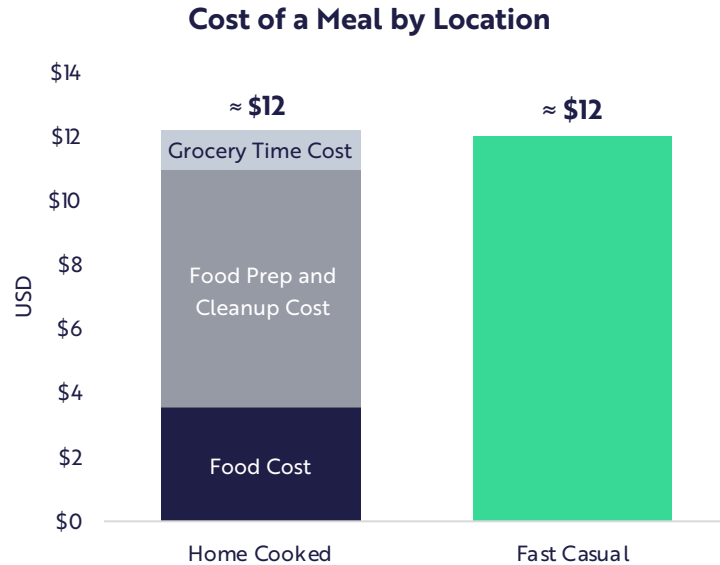
Source (Right Chart): ARK Investment Management LLC, 2019; Bridges, Dash. "I Made \$10,378 in 1 Year Working for DoorDash Part Time." The Rideshare Guy Blog and Podcast, 22 Aug. 2019, <https://arkinv.st/37osrPo>.

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# Robots Will Cause a Shift From “Unpaid” to “Paid” Labor

Automation systems can operate much of a fast-casual restaurant. Grocery shopping, food preparation, and clean-up will shift from “unpaid” tasks at home to paid jobs at fast-casual and other restaurants as well as their suppliers.



Forecasts are inherently limited and cannot be relied upon.  
Source: ARK Investment Management LLC, 2019; “Food Expenditure Series.” USDA ERS - Food Expenditure Series, <https://arkinv.st/2sptBve>.



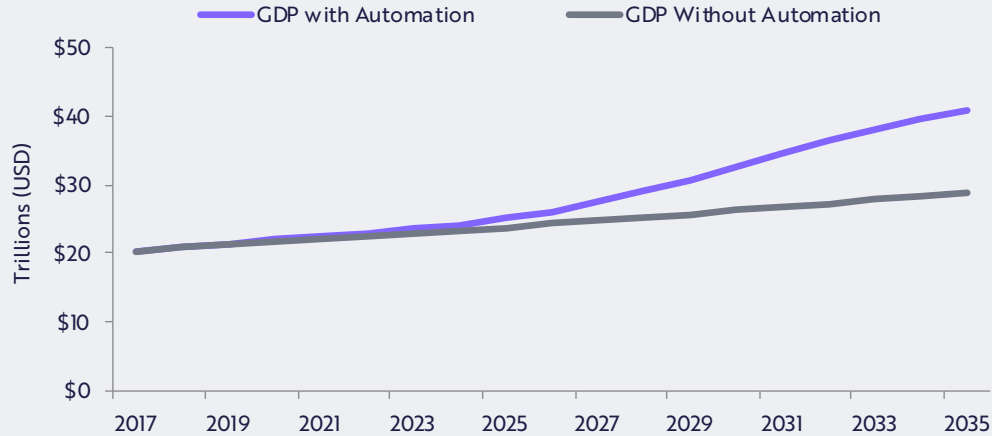


# Sizing the Opportunity



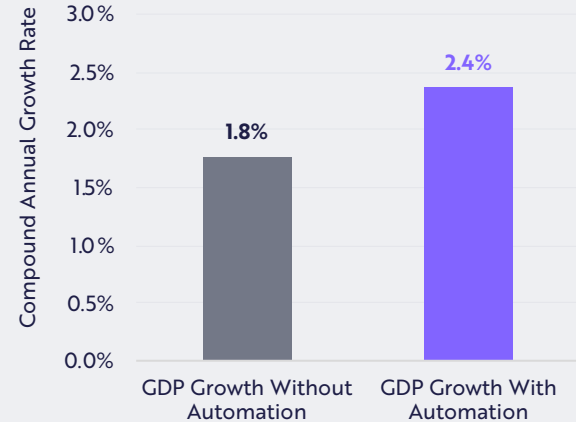
Automation could add **\$800 billion to US GDP** during the next five years and \$12 trillion during the next 15 years. By 2035, GDP could hit \$40 trillion, nearly 40% higher than would be the case without automation, compounding at a 2.4% growth rate instead of 1.8%.

### US GDP With and Without Automation



### US Real GDP Growth (CAGR)

2019 - 2024



Forecasts are inherently limited and cannot be relied upon.  
Source: ARK Investment Management LLC, 2019; "The Future of Employment: How Susceptible Are Jobs to Computerisation?" Oxford Martin School, <https://arkinv.st/2rFJJYW>.



# 3D Printing

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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 creates products with radically new architectures and less waste, at a fraction of the cost of traditional manufacturing.

**ARK believes 3D printing will revolutionize manufacturing, growing from \$10 billion in 2018 to \$97 billion in 2024 at an average annual rate of 65%.**

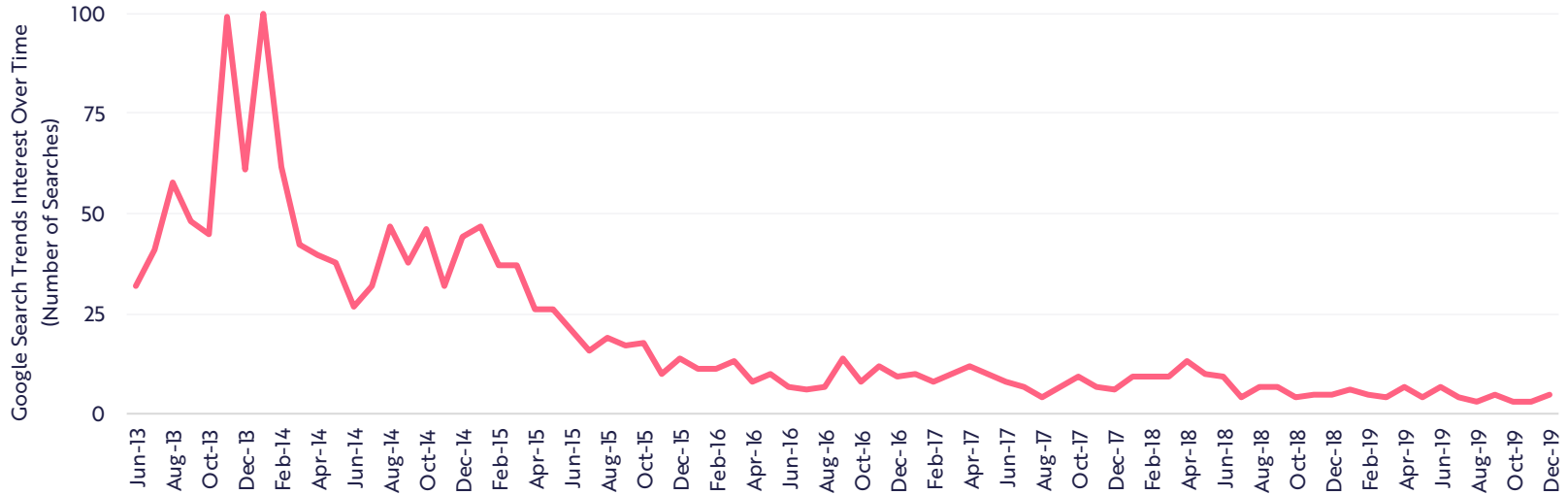




# Investors Seem to Be Underestimating 3D Printing

3D printing companies have not recovered from the consumer-3D printing hype of 2013-2014. As they have entered the so called “valley of despair,” 3D printing stocks have suffered from a lack of interest, creating a mismatch between the valuation of public and private companies in the space.

Google Trends "3D Printing Stocks"<sup>1</sup>  
(Category: Finance, Worldwide)



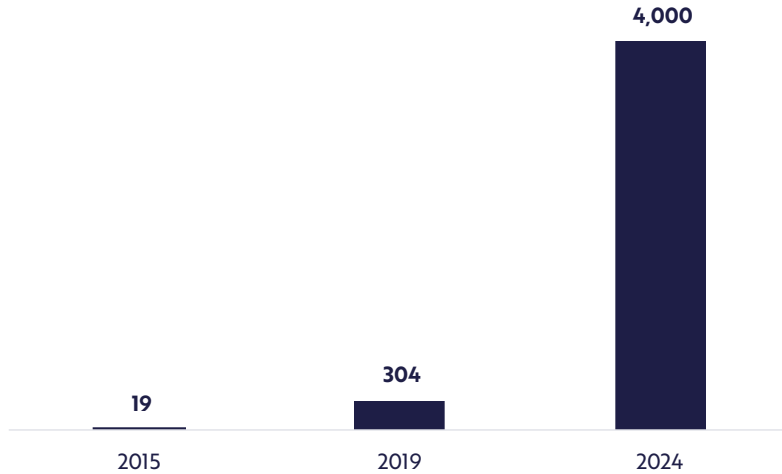
[1] ARK used Google Search Trends to illustrate the decline in investor interest for 3D printing stocks. While this analysis is limited, it mirrors the general investor sentiment for 3D printing stocks and their price decline. Source: ARK Investment Management LLC, 2019; Data sourced from <https://trends.google.com/>.



# The Adoption of 3D Printing Is at a Tipping Point

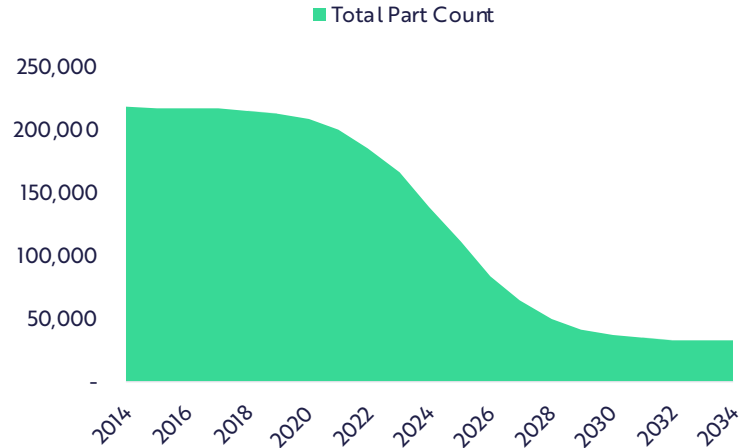
In 2015, General Electric (GE) produced the first 3D printed fuel nozzle, combining 20 parts into one.<sup>1</sup> In 2019, the GE9X engine contained 304 3D printed parts.<sup>2</sup> At that rate of adoption, and adjusting for the reduction in complexity, a large percentage of the GE9X engine could be 3D printed by the late 2020s.

### 3D Printed Parts in One Aircraft Engine\*



\*Note: There are 19 fuel nozzles per engine

### 3D Printing Reduces The Number of Parts Required For An Aircraft Engine



[1] Kellner, Tomas. "How 3D Printing Will Change Manufacturing." GE Reports, 16 Feb. 2018, <https://arkinv.st/2MQQNcJ>.

[2] Donaldson, Brent. "Mission Critical: An Additive Manufacturing Breakthrough in Commercial Aviation." Additive Manufacturing, 20 May 2019, <https://arkinv.st/2ZlqYAP>.

Forecasts are inherently limited and cannot be relied upon. | Source: ARK Investment Management LLC, 2019. Data sourced from Bloomberg.



# 3D Printing Enables Leaps In Manufacturing

Companies like Relativity Space use 3D printing, robotics, and AI to optimize production, improve quality, reduce manufacturing time, lower costs, and create designs previously not possible.

## Advancements in Aerospace Through Disruptive Technologies — Case Study: Terran 1 Rocket

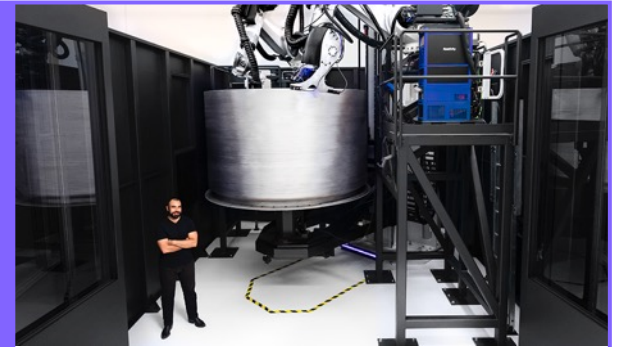


### Traditional Manufacturing

- 100,000+ Parts
- 24 Months Build Time
- 48 Months Iteration Time
- Human Designed Parts
- Complex Supply Chain
- Static Manufacturing Process

### 3D Printed Rocket Manufacturing

- < 1,000 Parts
- 2 Months Build Time
- 6 Months Iteration Time
- Computer Generated Design
- Simplified Supply Chain
- AI Continuously Improves Manufacturing Process



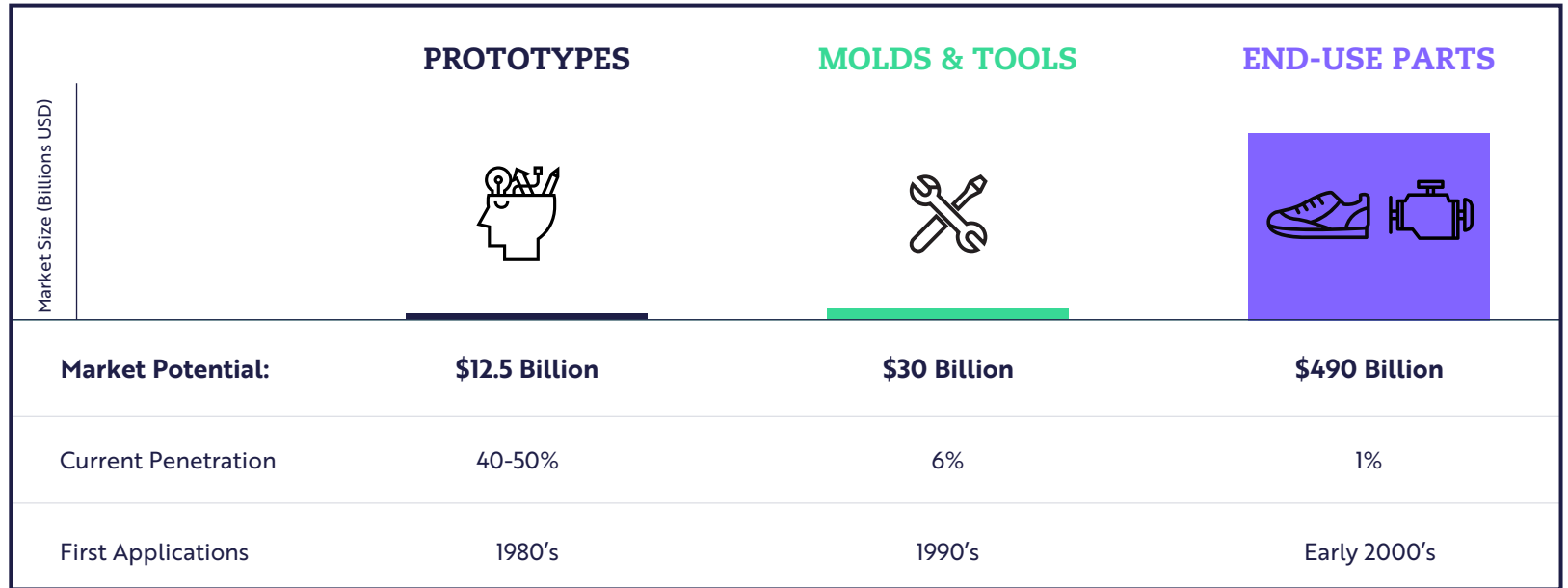
TERRAN 1 ROCKET BUILT AND FLOWN IN DAYS INSTEAD OF YEARS

Disrupts 60 years of aerospace by incorporating the world's largest metal 3D printers and AI-driven controls to build rockets in less than one year.



# ARK Believes 3D Printing Still Is in Its Infancy

ARK's research shows 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, 2019; McKinsey; Stratasy; "3D Printing History." AV Plastics, 14 June 2018, <https://arkinv.st/2TC57HI>.

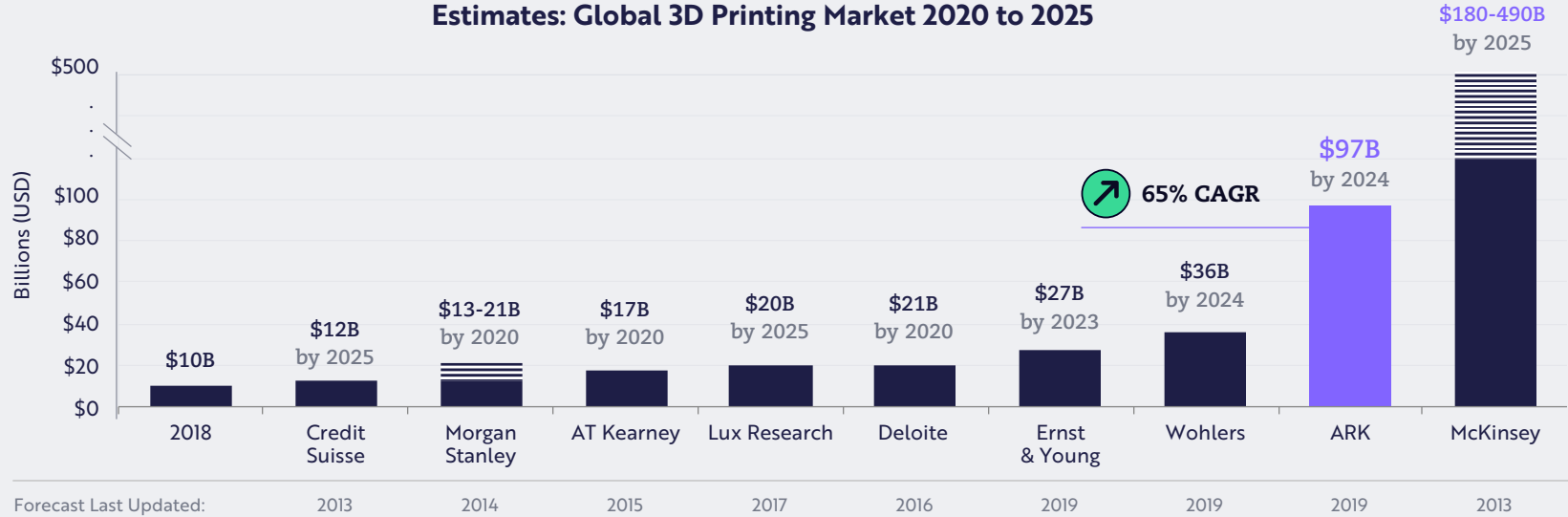


# Sizing the Opportunity



The global 3D printing market could scale to **\$97 billion by 2024**, compounding at a 65% annual rate.

### Estimates: Global 3D Printing Market 2020 to 2025



Forecasts are inherently limited and cannot be relied upon. Source: ARK Investment Management LLC, 2019



# Autonomous Ridehailing

Robots that can move people and parcels from place to place should reduce the cost of point-to-point travel to 1/10th the cost of a taxi today. In urban areas, ARK believes autonomous ridehailing will become the norm and personal car ownership the exception, enabling new business models.

**While autonomous ridehailing should debut a year later than promised, ARK's research suggests that the 10-year net present value (NPV) of its cashflows is more than \$1 trillion today and should hit \$5 trillion by 2024 and \$9 trillion by 2029.**

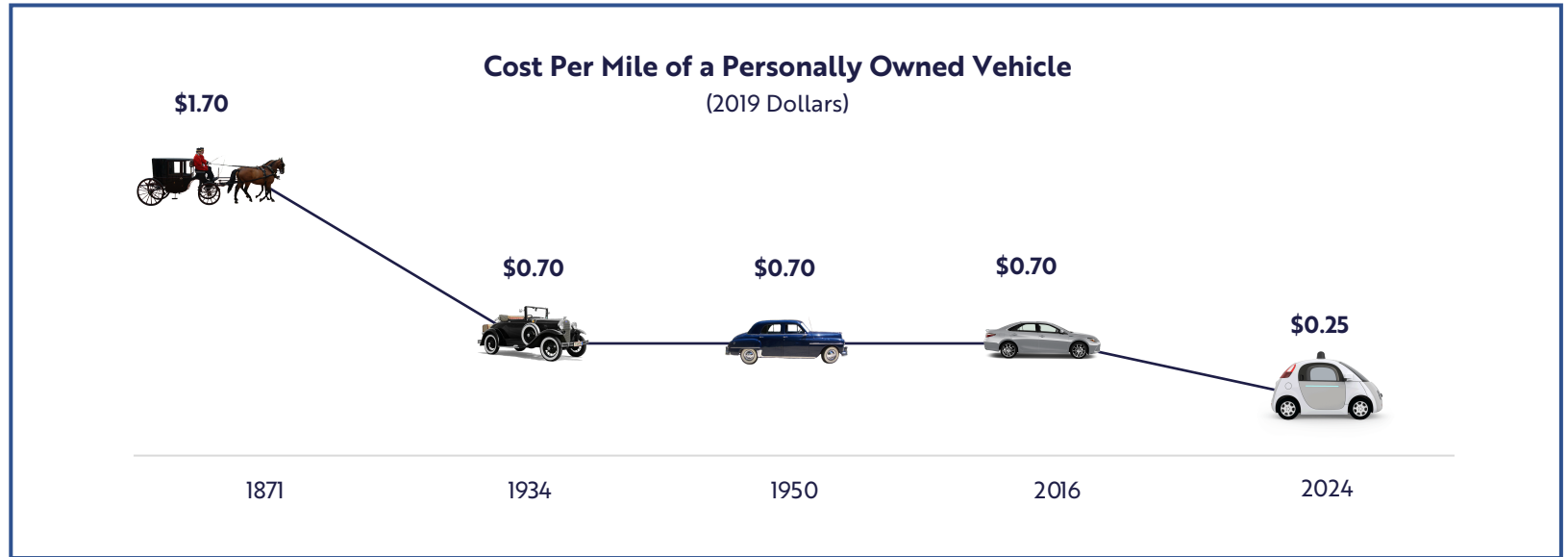






# Ridehailing Is Likely to Be Affordable

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.

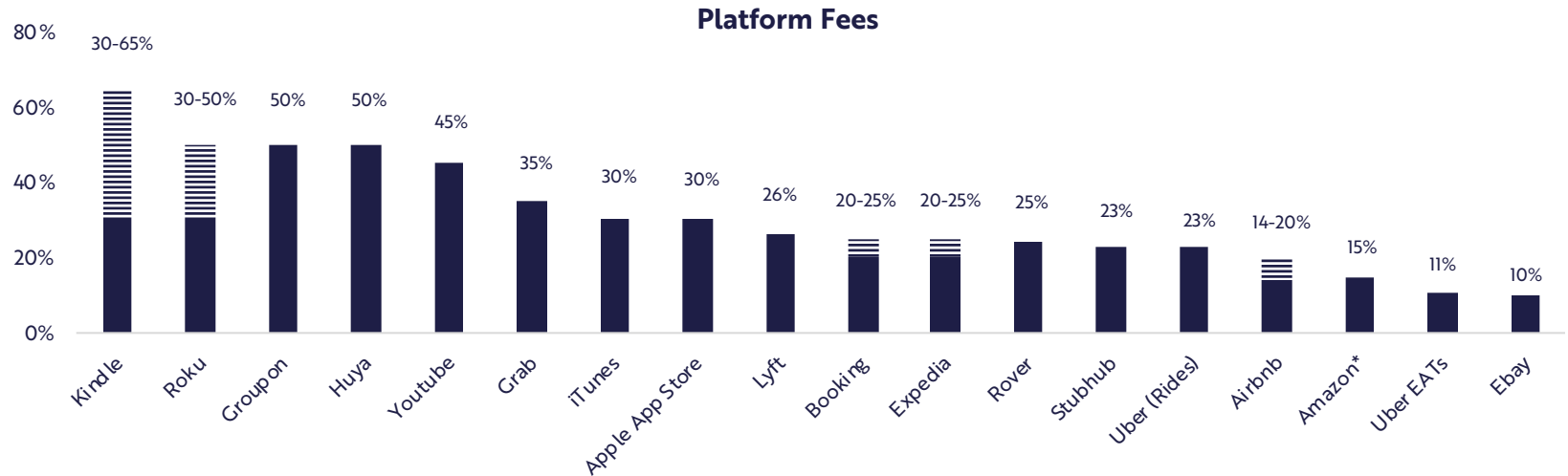


Note: ARK had estimated previously that an autonomous taxi could price at \$0.35 per mile. We have refined our estimates and believe that autonomous taxis could be even cheaper, at only \$0.25 per mile. Forecasts are inherently limited and cannot be relied upon. | Source: ARK Investment Management LLC, 2019; Morton Salt Company Records, American Automobile Association (AAA).



# Autonomous Platforms Could Command Take-Rates Exceeding 30%

Although ridehailing companies take 20-30% of revenues today, autonomous technology providers could collect higher fees as they provide more value to consumers through cheaper, safer, and more convenient services. Moreover, autonomous platforms should evolve in geographic monopolies, eliminating some of the competitive pressures that ridehailing companies are experiencing today.



\*Amazon From Third Party Sellers

Forecasts are inherently limited and cannot be relied upon. | Source: ARK Investment Management LLC, 2019

This is not a recommendation in relation to any named securities and no warranty or guarantee is provided. Any references to particular securities are for illustrative purposes only.

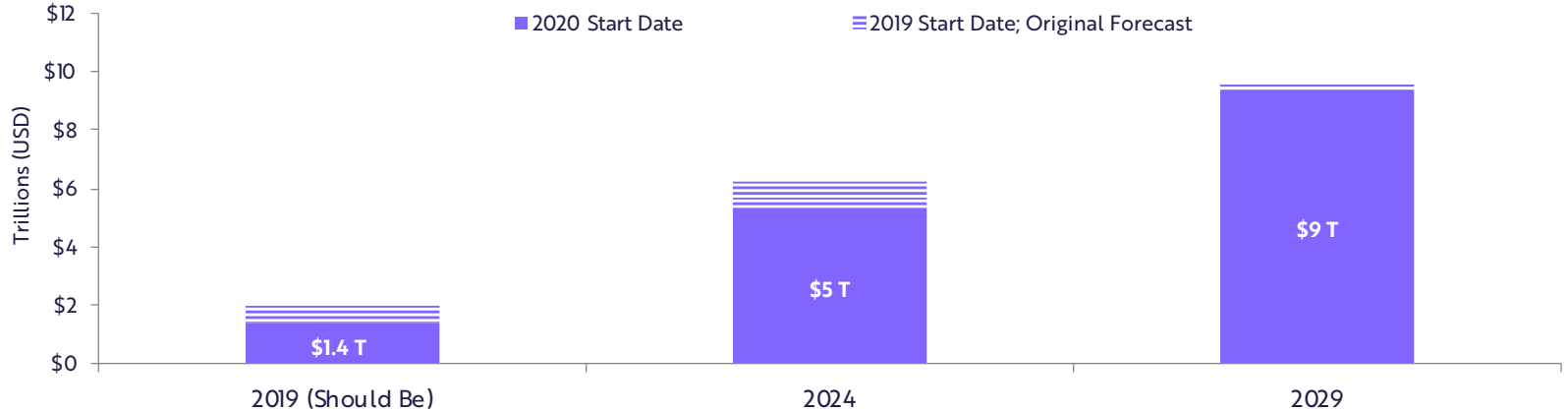


# The Winning Autonomous Ridehailing Platforms Should Be Worth Roughly \$1.4 Trillion Today

Based on Waymo’s and Cruise Automation’s missed deadlines for driverless commercial service, ARK pushed out its autonomous adoption curve by one year. If commercialization were to take place one year later than we had anticipated, future cashflows from autonomous ridehailing should be worth between \$1 - \$2 trillion today.

## Autonomous Ridehailing Cashflows During the Next 10 Years

(Estimated 10-Year Net Present Value, Cumulative)

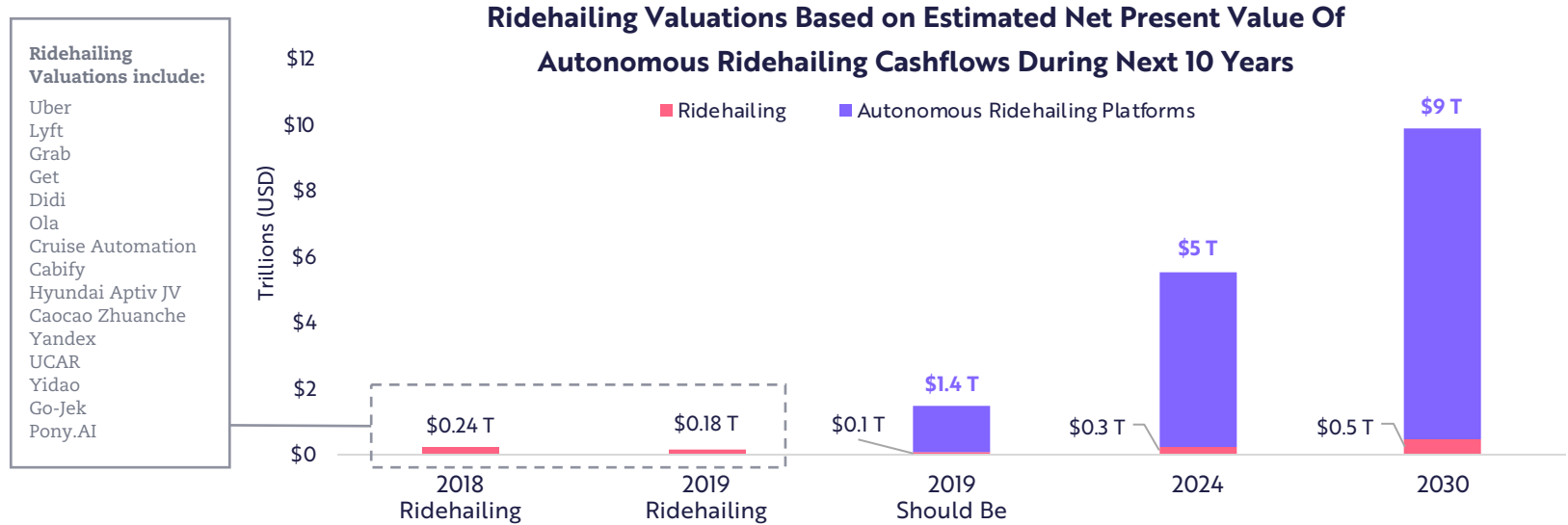


Forecasts are inherently limited and cannot be relied upon.  
Source: ARK Investment Management LLC, 2019



# Today's Ridehailing Companies Are Unlikely to Sustain Current Valuations In The Autonomous Future

Ridehailing company take-rates probably will drop from 20-30% today to 1-5% as they evolve into lead generators. The majority of fees will go to ridehailing platform providers that own and develop autonomous technology.



Forecasts are inherently limited and cannot be relied upon. | Source: ARK Investment Management LLC, 2019  
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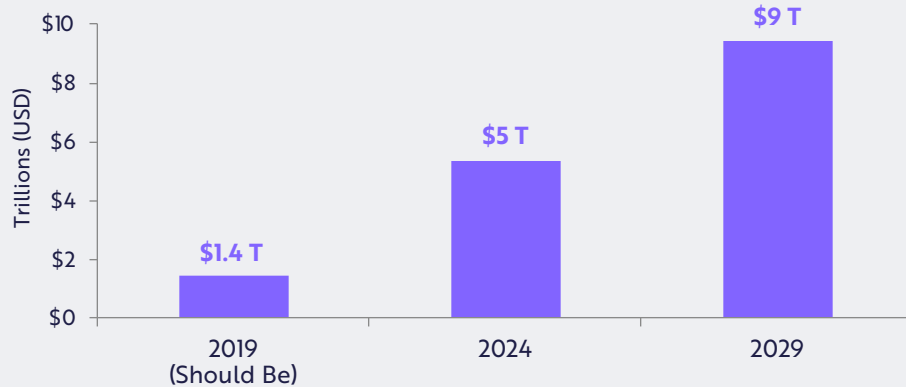


# Sizing the Opportunity

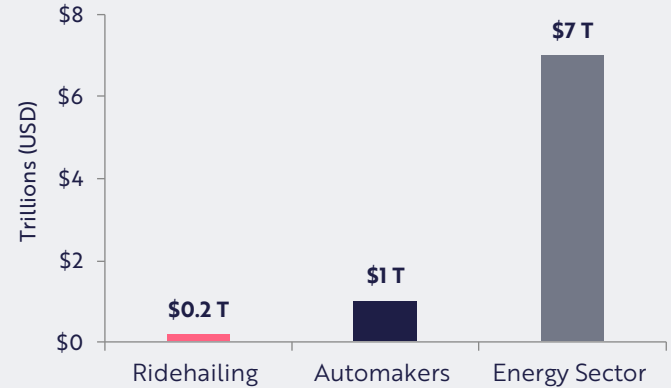


ARK believes that the autonomous ridehailing opportunity should be worth more than \$1 trillion dollars today, **\$5 trillion by 2024, and \$9 trillion by 2029.**

### Estimated Cumulative 10-Year Net Present Value Of Autonomous Ridehailing Cashflows



### Market Capitalization in 2019



Note: ARK's estimate for market capitalization is using our global adoption curve and revenue estimates, assuming software like margins and cash flow for platform operators, and discounting cash flows from 10 years forward. Forecasts are inherently limited and cannot be relied upon. | Source: ARK Investment Management LLC, 2019



# Aerial Drones

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Lower battery costs and autonomous technology should power aerial drones. Soon, ARK believes drones will deliver our packages, food, and even people quicker and more conveniently than ever before. Drones should change shopping behavior and reduce travel times while potentially saving lives.

**ARK believes that drone delivery platforms could generate roughly \$275 billion in delivery revenues, \$39 billion in hardware sales, and \$12 billion in mapping revenue by 2030.**

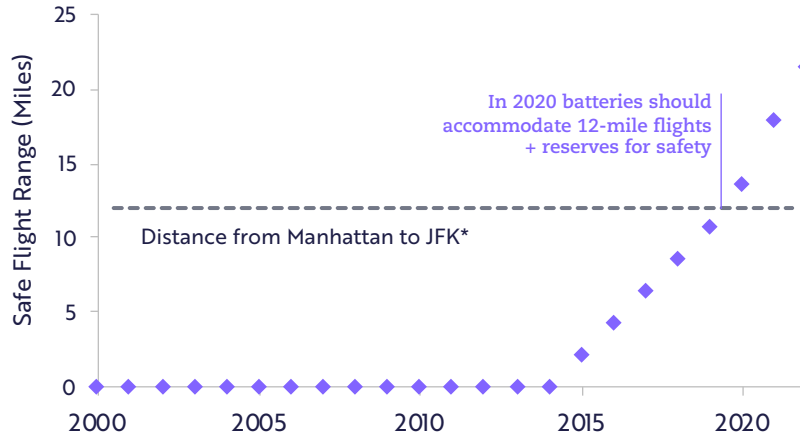




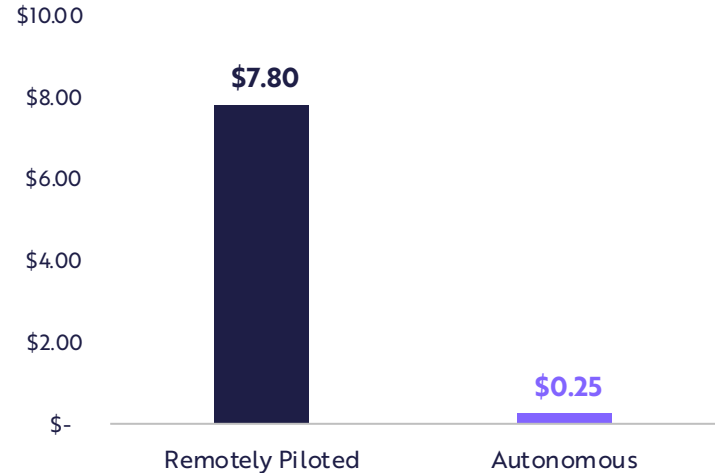
# Autonomous Air Travel Has Become Both Possible and Affordable

Battery technology is improving, enough so that flight reserves 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.

### Safe Passenger Drone Range (Inclusive of Flight Reserve For Safety)



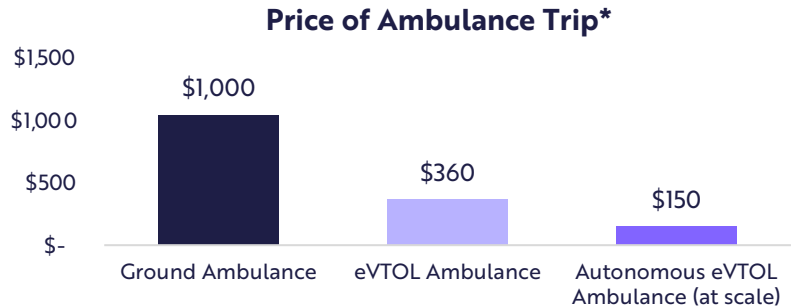
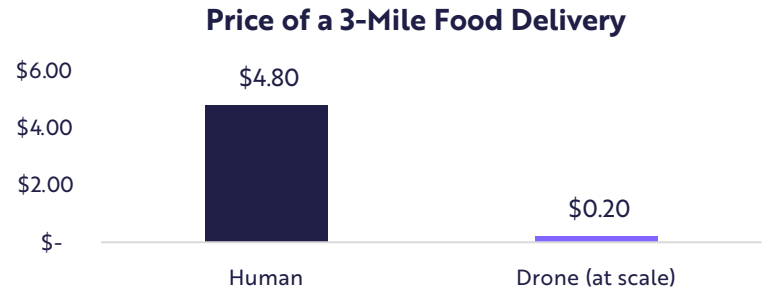
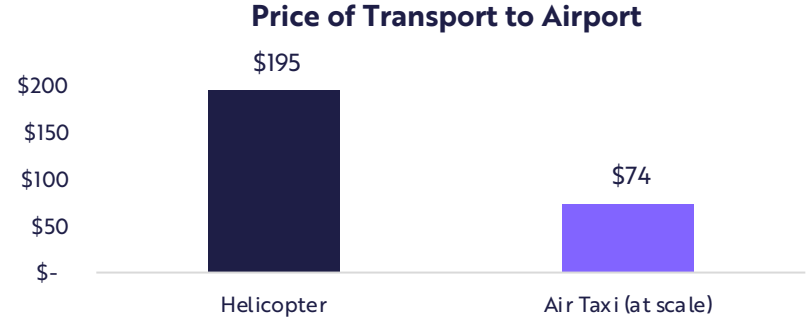
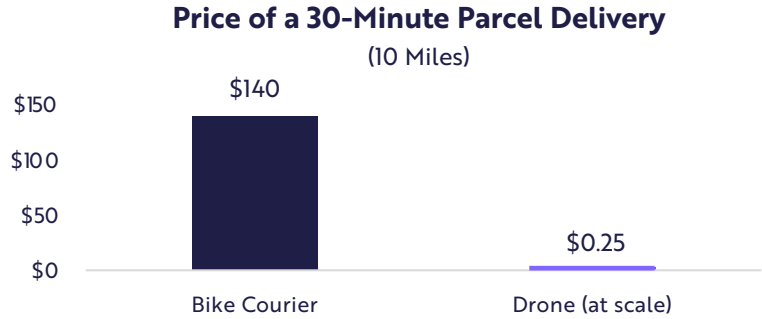
### Cost of a 10-Mile Drone Delivery\*\*



\*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, 2019



# The Cost To Transport People and Things Today Should Decline Dramatically as Drones Create New Markets



\*Ambulance transports patient to hospital and assumes eVTOL (electric vertical takeoff and landing) transports only first responder to patient. | 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. Source: ARK Investment Management LLC, 2019; Bridges, Dash. "I Made \$10,378 in 1 Year Working for DoorDash Part Time." The Rideshare Guy Blog and Podcast, 22 Aug. 2019, <https://arkinv.st/37osrPo>.

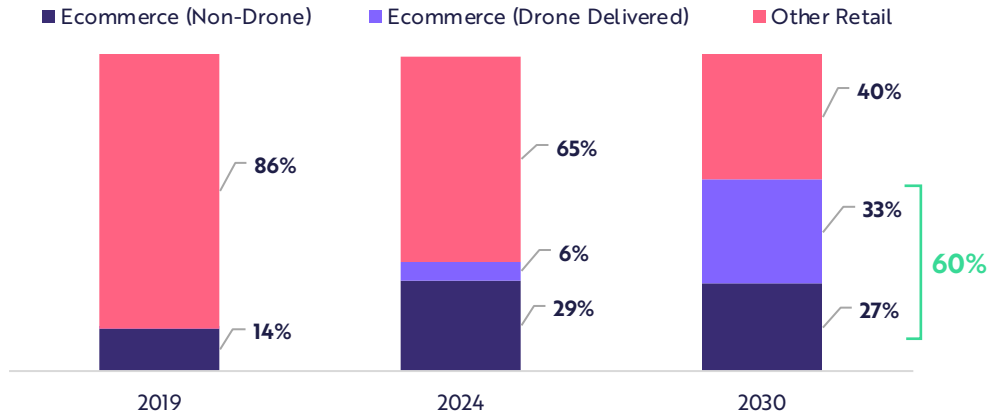




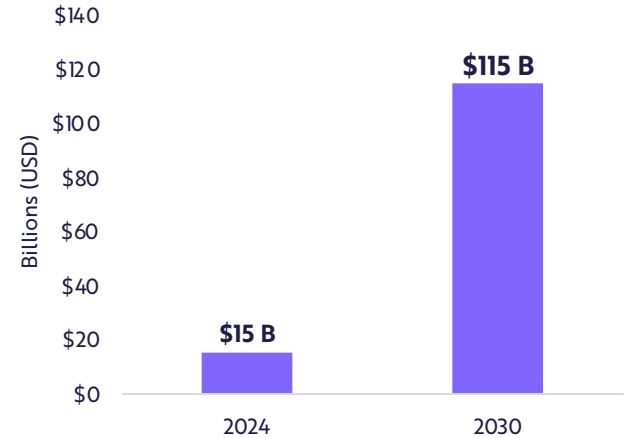
# Drone Delivery Should Take a Substantial Share of Ecommerce Volumes

Drones should make package delivery inexpensive: more purchase decisions made in-store could move online, pushing global ecommerce from 14% of retail sales in 2019 to 60% in 2030. At \$0.25 per delivery, autonomous parcel drone operators could be targeting a \$115 billion market opportunity by 2030.

### Global Share of Retail Sales (2019 and Forecasted)



### Global Parcel Drone Delivery Revenue



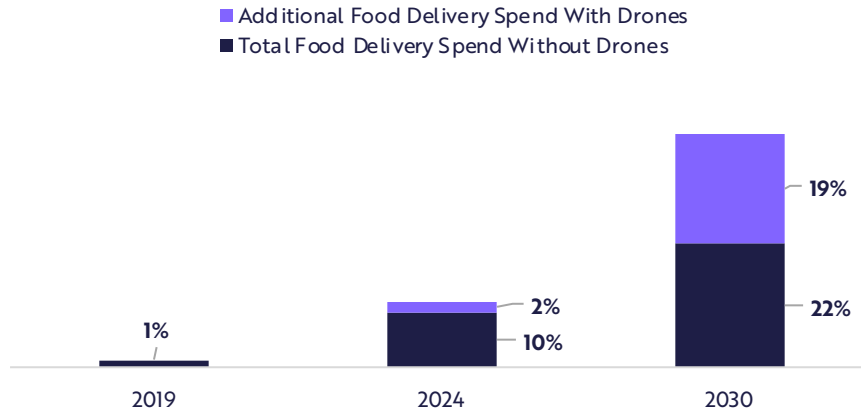
Forecasts are inherently limited and cannot be relied upon. | Source: ARK Investment Management LLC, 2019; "Pitney Bowes Parcel Shipping Index Reports Global Parcel Shipping Reaches \$279 Billion in Revenue." Pitney Bowes, 28 Aug. 2018, <https://arkinv.st/2QjSeSQ>; "Data and Research on Digital for Business 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>.



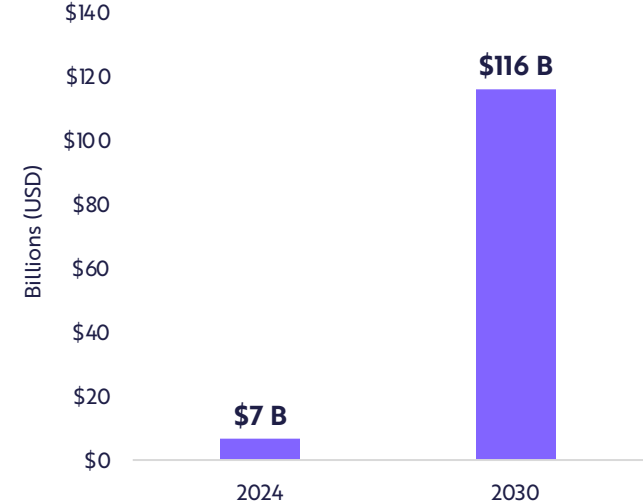
# Drones Could Cause an Inflection in Food Delivery

ARK believes that food is a good candidate for drone delivery, as it is lightweight and time sensitive. We estimate that revenue from drone food delivery could total roughly \$116 billion globally by 2030.

### Global Food Delivery as a Percent Of Total Food Spending With and Without Drones (2019 and Forecasted)



### Global Food Drone Delivery Revenue



Forecasts are inherently limited and cannot be relied upon. | Source: ARK Investment Management LLC, 2019; "Euromonitor International: Strategic Market Research, Data & Analysis." Euromonitor International | Strategic Market Research, Data & Analysis, <https://arkinv.st/2udM3HB>; "Food Expenditure Series." USDA ERS - Food Expenditure Series, <https://arkinv.st/39AmNLF>; "Measurement of Food Away From Home (FAFH) In Household Surveys." World Bank Surveys, Nov. 2017, <https://arkinv.st/2FaRyZV>; Food Data Collection in Household Consumption and Expenditure Surveys. The Inter-Agency and Expert Group on Food Security, Agricultural and Rural Statistics and Endorsed by the Forty-Ninth Session of the United Nations Statistical Commission, 29 Mar. 2018, <https://arkinv.st/36mEUm>; Fabiosa, Jacinto F., "The Food-Away-from-Home Consumption Expenditure Pattern in Egypt" (2008). CARD Working Papers. 503. <https://arkinv.st/2ZLnBJt>.



# Electric Air Taxis Should Provide Faster and Cheaper Transport, Especially Above Traffic Bottlenecks

Cost and Convenience of Travel Options From Manhattan to JFK\*



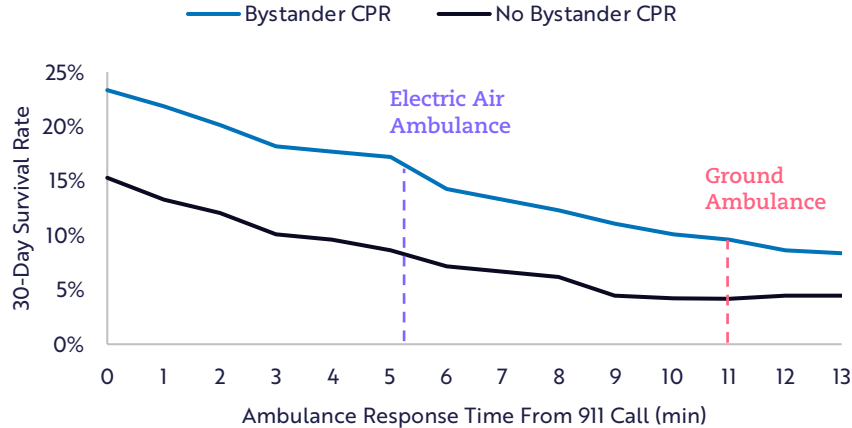
\*JFK – John F. Kennedy International Airport  
Forecasts are inherently limited and cannot be relied upon. | Source: ARK Investment Management LLC, 2019



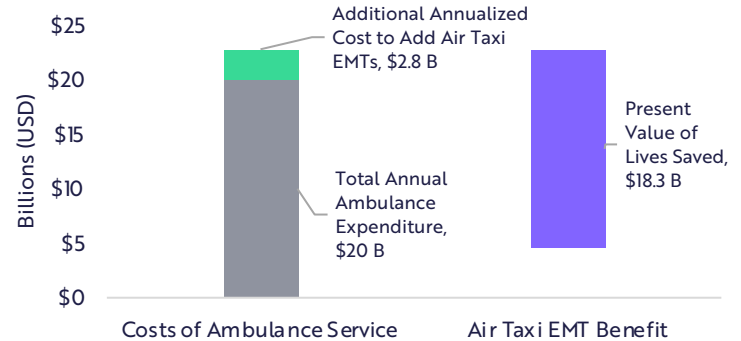
# Electric Air Taxis Could Be a Cost-Effective Way to Save Lives

Each year in the US roughly 350,000 cardiac arrests occur outside of hospitals, with only 12% of the victims surviving. Drones could save up to 20,000 lives annually by decreasing response times. Based on the present value of lives saved, if the air ambulance service were to cost an additional \$150 per patient, the annual cost would be an incremental \$2.8 billion in the US. The benefit associated with lives saved would be more than six times the cost.

### Survival Rate by Ambulance Response Time



### Adding Air Taxi EMTs to Existing Ambulance Fleet: Estimated Lives-Saved and Cost Benefit



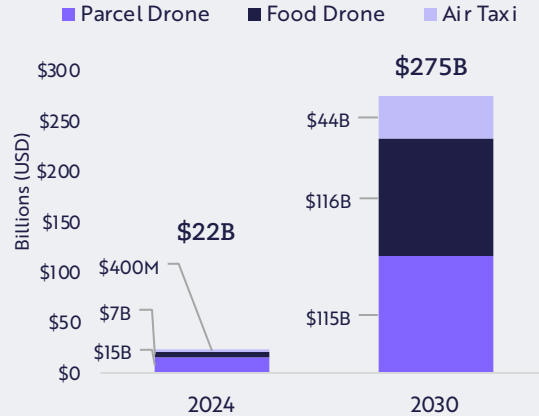
Forecasts are inherently limited and cannot be relied upon. Source: ARK Investment Management LLC, 2019



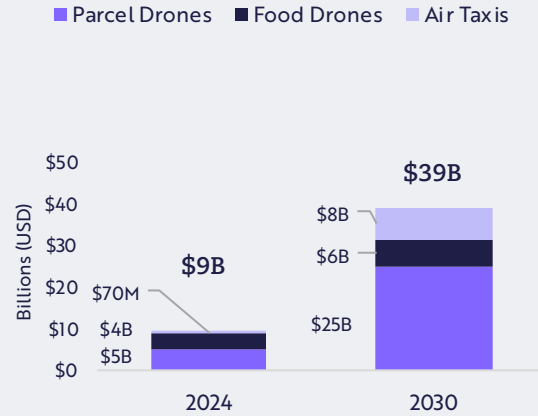
# Sizing the Opportunity

Drone delivery platforms could generate **\$275 billion in delivery revenue, \$39 billion in hardware sales, and \$12 billion in mapping revenue by 2030.**

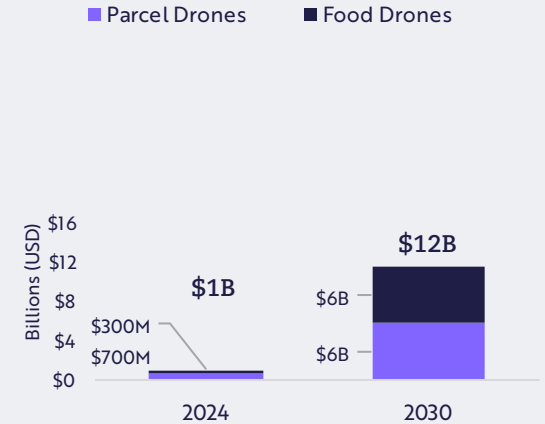
### Delivery Revenue



### Drone Hardware Sales



### Mapping Revenue



Forecasts are inherently limited and cannot be relied upon. Source: ARK Investment Management LLC, 2019



# Next Generation DNA Sequencing

Next-generation DNA sequencing (“NGS”) is the driving force behind the genomic revolution. Since 2003 the cost to sequence a human genome has dropped from nearly \$3 billion to less than \$1,000.

ARK believes that as costs continue to drop, NGS will become a standard of care in oncology. It will introduce more science into healthcare decision-making, enable personalized medicine, and accelerate drug discovery.

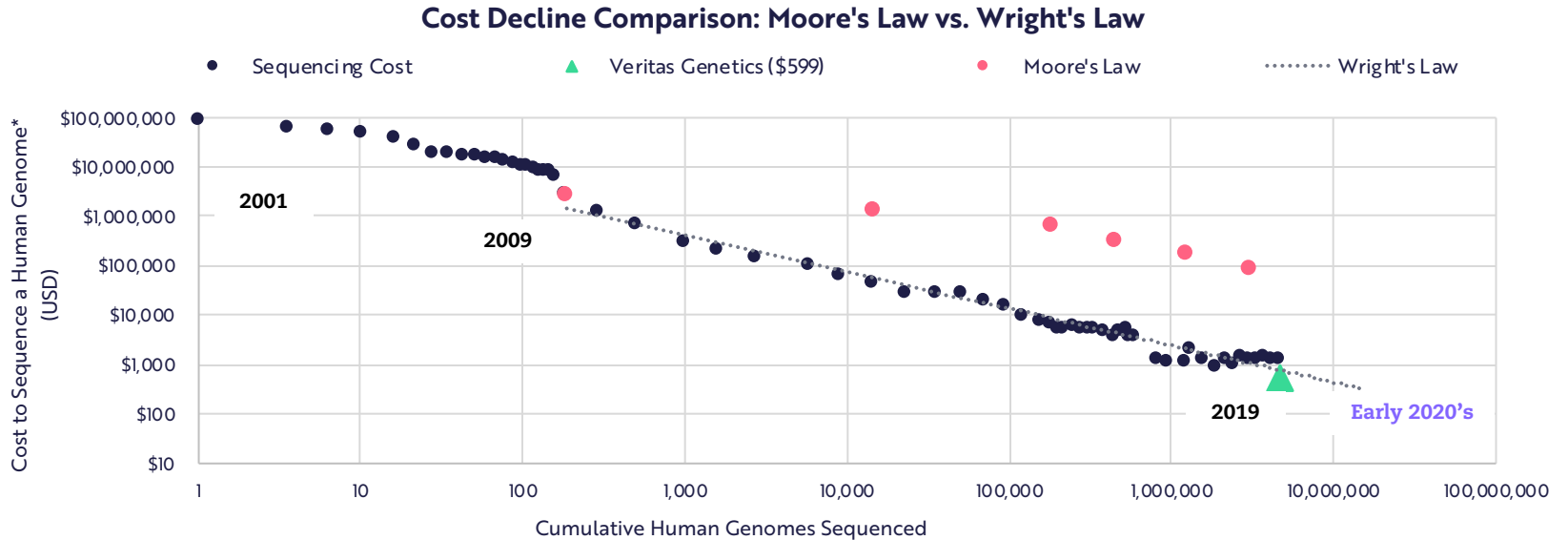
**ARK estimates that NGS revenues will grow 43% at an annual rate, from \$3.5 billion last year to \$21 billion in 2024.**





# The Cost of DNA Sequencing Is Declining Precipitously

ARK believes that NGS costs are declining at a rapid rate, following Wright's Law: for every cumulative doubling in units produced, costs decline 40%. If NGS had followed Moore's Law since 2009, the cost to sequence a whole human genome today would be \$100,000—more than two orders of magnitude higher than the \$1,000 that Wright's Law predicted.



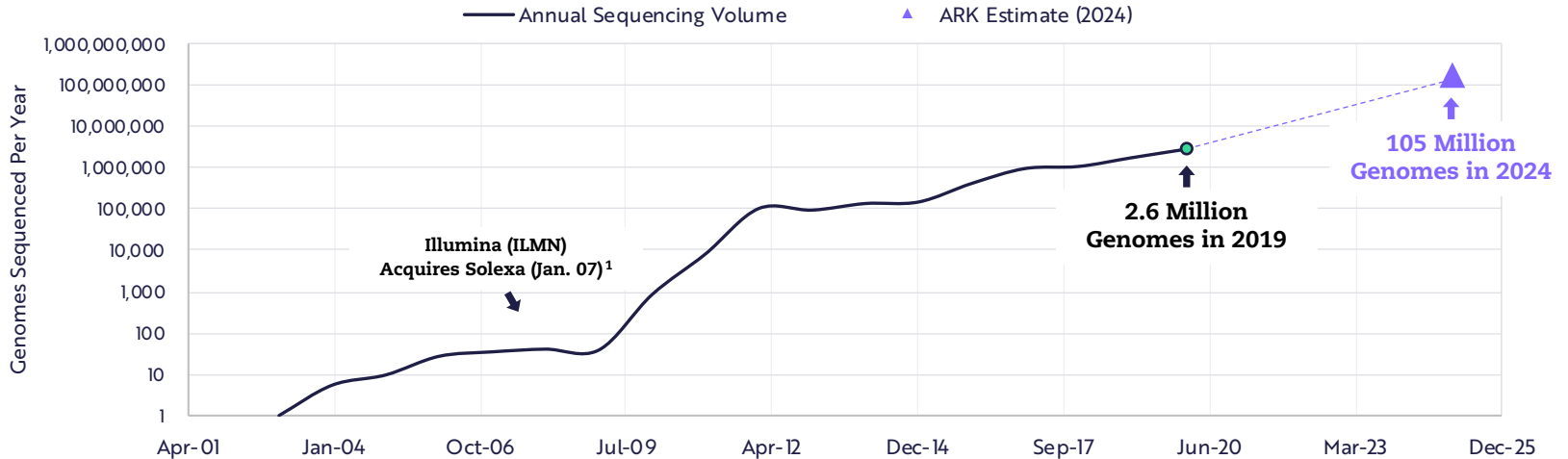
\*Human genome data equivalents equate to 96 gigabases of sequence data. Forecasts are inherently limited and cannot be relied upon. | Source: ARK Investment Management LLC, 2019; "The Cost of Sequencing a Human Genome." Genome.gov, <https://arkinv.st/2SIImMzm>. This is not a recommendation in relation to any named securities and no warranty or guarantee is provided. Any references to particular securities are for illustrative purposes only.



# As Costs Decline, Demand for Sequencing Is Surging

ARK believes that the number of whole human genomes sequenced per year should scale 110% at an annual rate, from roughly 2.6 million in 2019 to 105 million in 2024, thanks to the clinical adoption of molecular diagnostics. Among these sequencing-intensive tests are: liquid biopsies, solid tumor profiling, germline testing, immune-oncology, and non-invasive prenatal screening.

### Annual Sequencing Volume Is Accelerating as NGS Enters Clinical Practice



[1] Illumina combined its technology with Solexa's to commercialize the first wave of NGS instruments. Forecasts are inherently limited and cannot be relied upon. | Source: ARK Investment Management LLC, 2019; "The Cost of Sequencing a Human Genome." Genome.gov, <https://arkinv.st/2SlmMzm>. This is not a recommendation in relation to any named securities and no warranty or guarantee is provided. Any references to particular securities are for illustrative purposes only.





# Next Generation Sequencing Should Transform Clinical Oncology

NGS enables clinicians to gauge an individual's risk of cancer, treat diagnosed patients, and monitor disease recurrence more precisely.



## Undiagnosed Patients

Combined with other electronic healthcare data, genetic information could identify cancer in Stage 1.

### Germline Risk Assessment

### Patient-Centric Monitoring via Liquid Biopsy

### Less-Invasive Tissue Profiling



## Diagnosed Patients

NGS enables sophisticated tumor profiling and precision therapies throughout the course of treatment.

### Somatic Tissue Testing

### Liquid Biopsy for Advanced Disease

### Therapy Matching



## Patients in Remission

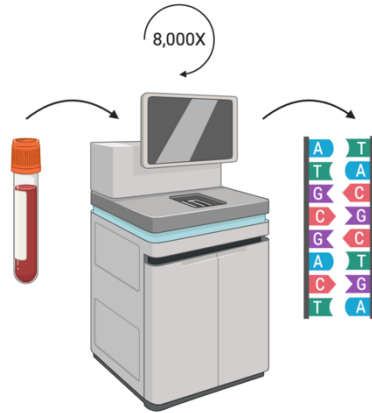
NGS can monitor patients in remission noninvasively and frequently to identify recurrences.

### Recurrence Monitoring via Liquid Biopsy



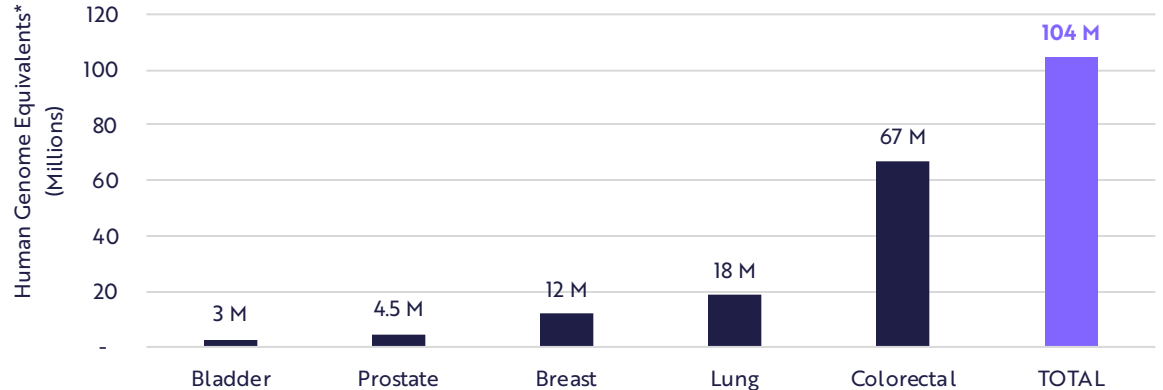
# Liquid Biopsies Add to Oncologists' Toolkits

Liquid biopsies sequence tumor-derived DNA fragments (ctDNA) circulating in the bloodstream. Oncologists use this information, matching patients to therapies without the need for invasive tissue biopsies. Clinical trials are under way to increase the utility of liquid biopsies, not only to screen for cancer but also to monitor patients in remission for recurrences. As a result, sequencing intensity is increasing.



Liquid biopsies are sequencing-intensive, meaning that samples need to be analyzed many times for an accurate result.

## Recurrence Monitoring Alone Could Magnify Annual Sequencing Volume by Roughly 40X\*\*



\*Human genome equivalents equate to 96 gigabases of sequence data. | \*\*Full penetration of 104 million human genomes is equal to a 40x increase in annual sequencing intensity as measured in 2019 (2.6 million human genomes). Source: ARK Investment Management LLC, 2019, "Potential Utility of Liquid Biopsy as a Diagnostic and Prognostic Tool for the Assessment of Solid Tumors: Implications in the Precision Oncology." Journal of Clinical Medicine, 18 Mar. 2019, <https://arkinv.st/359hcZD>; Chamie, Karim, et al. "Recurrence of High-Risk Bladder Cancer: a Population-Based Analysis." Cancer, U.S. National Library of Medicine, 1 Sept. 2013, <https://arkinv.st/39w7aVy>; "Bladder Cancer." Mayo Clinic, Mayo Foundation for Medical Education and Research, 22 Dec. 2017, <https://arkinv.st/2rJ3v5P>; "Survivorship Care Plans." American Cancer Society, <https://arkinv.st/36bTzAY>.



# Sizing the Opportunity

ARK believes that the average price to sequence a whole human genome will fall to roughly \$200 by 2024.<sup>1</sup>

Based on Wright's Law, ARK estimates that NGS revenues could grow at an annual rate of 43%, reaching

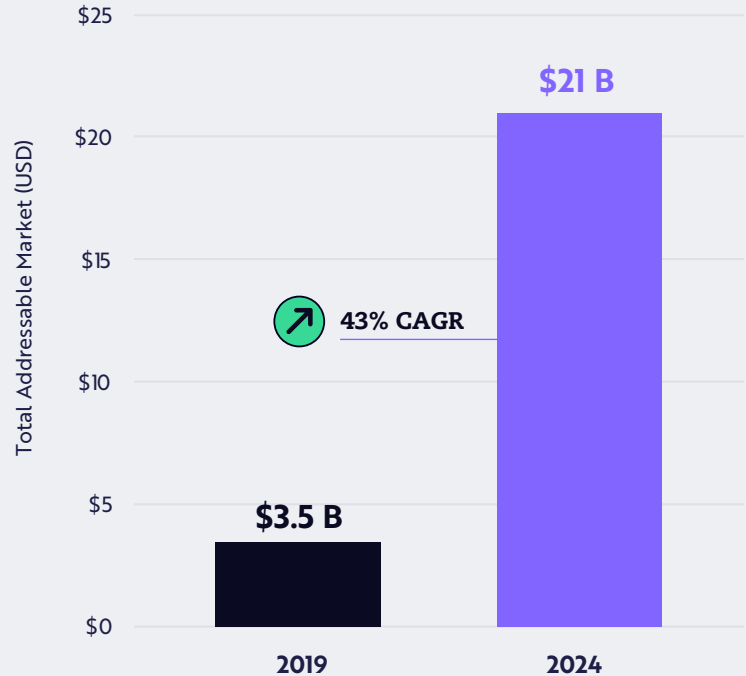
**\$21 billion in 2024.**

[1] ARK adjusted its previous cost of \$100 by 2023. We believe market leaders in this space are not lowering costs as quickly as they could. In addition, the average selling price is inclusive of labor, hardware amortization, consumables and other associated costs, as the National Institutes of Healthcare (NIH) recently delineated.

Forecasts are inherently limited and cannot be relied upon. | Source: ARK Investment Management LLC, 2019



## DNA Sequencing Market





# Biotech R&D Efficiency

The convergence of Artificial Intelligence (AI), Next Generation DNA Sequencing (NGS) and CRISPR gene-editing has the potential to boost the efficiency of drug development radically. It should shorten development timelines, reduce failure rates, and increase returns on R&D in the search for disease cures.

**ARK's research shows that the convergence of AI, NGS, and CRISPR gene-editing could add trillions to the market capitalization of the Biotech and Pharmaceutical industries, while creating a more efficient healthcare system.**





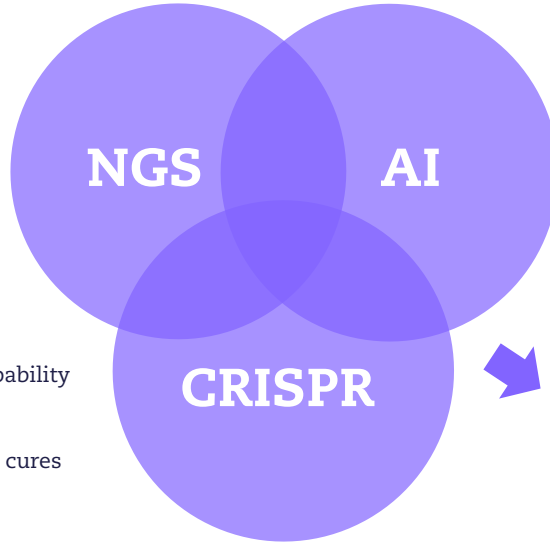
# Three Technological Advances Could Boost the Efficiency of Drug Development Radically

## Next Generation Sequencing

- Sequences faster and cheaper, with higher fidelity
- Guides patients toward targeted treatments
- Improves clinical trial selection

## CRISPR Gene-Editing

- Edits faster and cheaper, with more capability
- Enables earlier experimentation
- Turns chronic conditions into potential cures



## Artificial Intelligence

- Accelerates the discovery of drug candidates
- Increases clinical trial participation
- Lowers the cost of sequencing and analysis

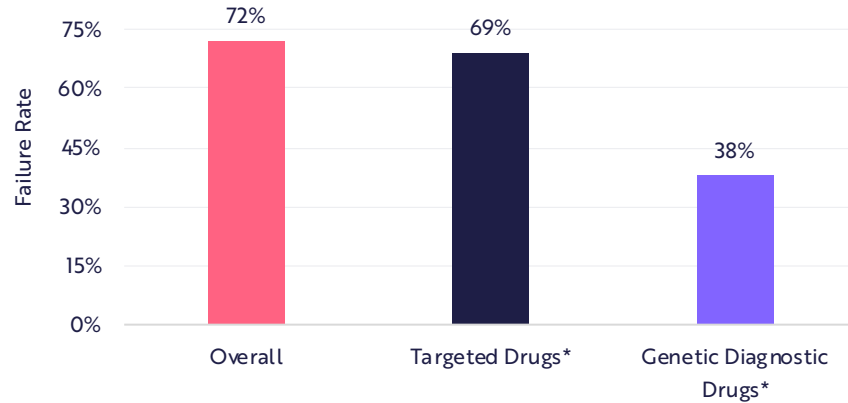
Cures for chronic conditions  
Fewer failures in drug development  
Shorter development timelines



# Next Generation DNA Sequencing (NGS) Is Critical to Clinical Trial Success Rates

Drug development companies are making clinical trials more efficient by using NGS to find and enroll patients likely to respond. Half of clinical trials and 80% of oncology trials now collect genetic information. ARK believes clinical trials using genetic diagnostics will result in fewer failed drugs and will increase capital efficiency.

### Genetic Diagnostics Can Lower Failure Rates by 45% in Phase III Lung Cancer Trials



### The Cost to Produce One FDA-Approved Drug Given Reduced Failure Rates

Failure Rate Reduction (%)	Failed Drugs (#)	Total Cost of R&D <sup>1</sup> (Million USD)
0	28	\$720
10	18	\$520
25	9	\$350
45	3	\$220

Next generation sequencing diagnostic tests, in combination with artificial intelligence, should reduce clinical trial failure rates materially at every stage of the drug development process

[1] Assumes 10% cost of capital.

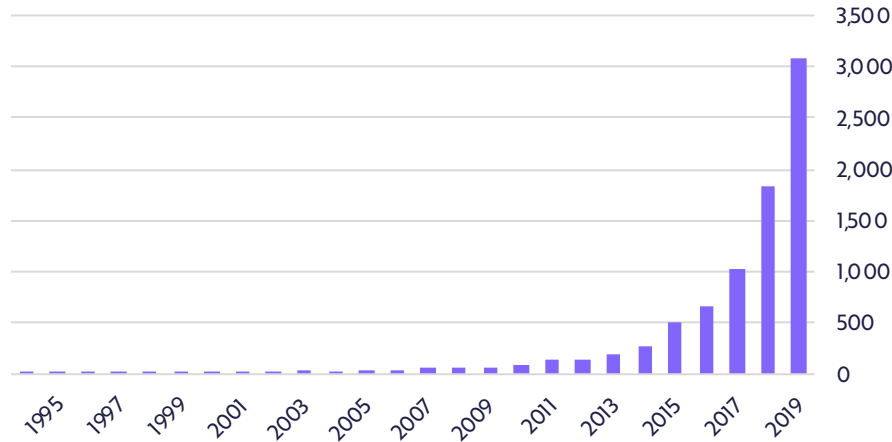
\*A lower failure rate constitutes an improvement in clinical trial success. Targeted drugs have a mechanism of action that usually is genetic in nature and tailored to a patient. Source: ARK Investment Management LLC, 2019; Falconi, Adam, et al. "Biomarkers and Receptor Targeted Therapies Reduce Clinical Trial Risk in Non-Small-Cell Lung Cancer." Journal of Thoracic Oncology, Elsevier, 20 Nov. 2015, <https://arkinv.st/35AnSA2>.



# Artificial Intelligence (AI) Should Reduce the Time-to-Market for New Therapies

AI is being deployed increasingly to address major diseases and to boost efficiency throughout the healthcare ecosystem. AI should increase clinical trial throughput by improving patient recruitment and retention, potentially cutting trial times by more than half.

**Publication Volume of Machine Learning and Deep Learning Papers Focused on Major Diseases<sup>1</sup>**



**Cost To Develop A Single Successful Drug**

Time-to-Market Reduction (%)	Total Cost of R&D <sup>2</sup> (Million USD)
0	\$720
10	\$675
25	\$610
45	\$535

The combination of AI, DNA sequencing, and gene editing should improve clinical trial speed and lower cost-of-capital adjusted R&D costs.

[1] Academic papers mentioning "machine learning" or "deep learning" and one of the top 5 mortal diseases in the US in the title or abstract

[2] Assumes 10% cost of capital.

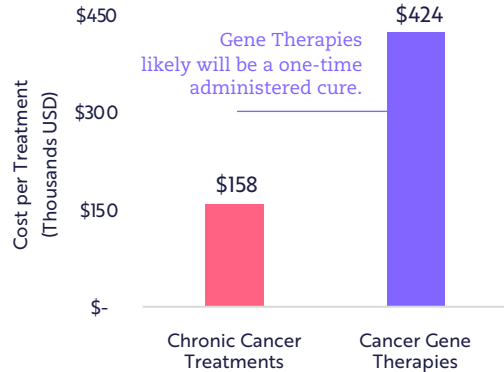
Source: ARK Investment Management LLC, 2019; "Home - PubMed - NCBI." National Center for Biotechnology Information, U.S. National Library of Medicine, <https://arkinv.st/2ZZk9L4>.



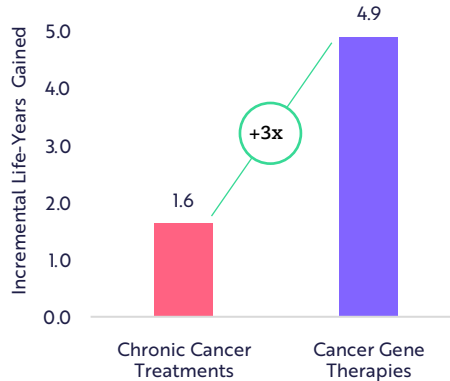
# Curing Disease Comes at a Higher Sticker Price But a Much Better Bang For the Buck

Gene editing promises to transform our ability to create and deliver gene and cell therapies. To date, only 10 therapies have been FDA approved—three of them targeting cancer—but more than 2,000 trials have been registered. Approved by the FDA in the last two years, the first three gene therapies demonstrated high rates of complete remission in liquid tumors at a low cost per "life-year".<sup>1</sup>

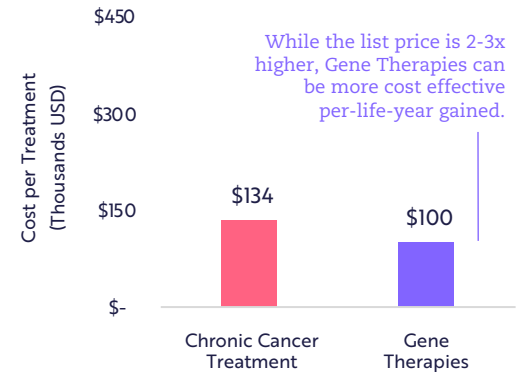
### Average Cost of Chronic Cancer Treatment<sup>2</sup> vs. Gene Therapies



### Average Life-Years Gained by Treatment Paradigm



### Average Cost of Cancer Care Per Life-Year Gained



[1] Life-year: Year of survival while on therapy. [2] Chronic cancer treatments include treatments approved 2014 to 2019. Source: ARK Investment Management LLC, 2019; Biologics Evaluation and Research. "Approved Cellular and Gene Therapy Products." U.S. Food and Drug Administration, FDA, <https://arkinv.st/37LrKQh>; Shahryari, Alireza, et al. "Development and Clinical Translation of Approved Gene Therapy Products for Genetic Disorders." Frontiers, Frontiers, 20 Aug. 2019, <https://arkinv.st/39MZ0xg>.

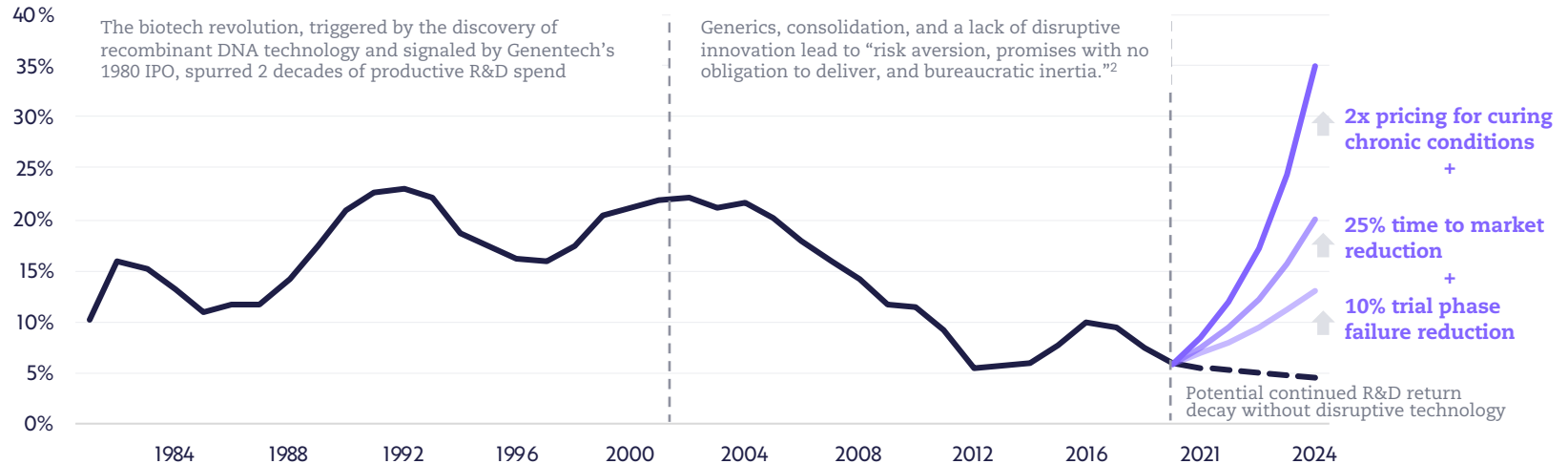




# The Combination of Sequencing, Editing and AI Could Reverse Decaying Returns on Therapeutic R&D

A marginal increase in clinical trial success rates coupled with an increase in trial throughput and the premium pricing afforded to curative therapies could catalyze returns to R&D not seen since the biotech revolution.

**Pharma and Biotech: Returns on Drug R&D<sup>1</sup> and Potential Trajectories**  
(5 Year Moving Average)



[1] Returns on Drug R&D = The rate of return, less the risk-free rate, on the R&D dollars spent (inclusive of drug failures) in the years leading up to drug releases and associated present value of earnings in any given year.

[2] Garnier, J-P. 2008. Rebuilding the R&D Engine in Big Pharma. Harvard Business Review May 2008.

Forecasts are inherently limited and cannot be relied upon.

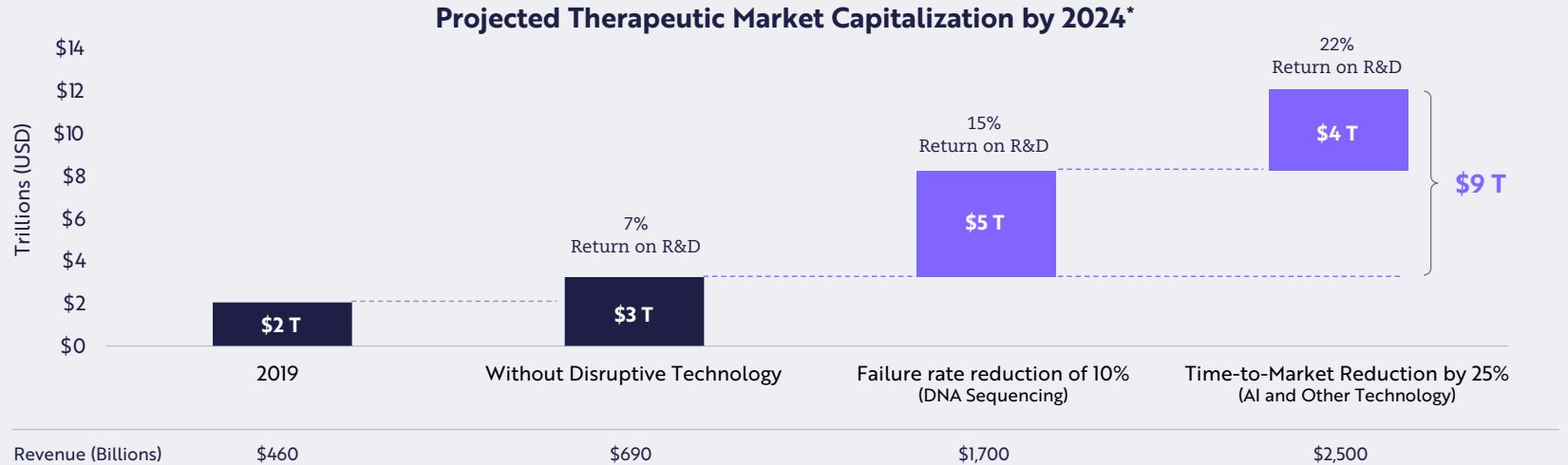
Source: ARK Investment Management LLC, 2019; Garnier, Jean-Pierre. "Rebuilding the R&D Engine in Big Pharma." Harvard Business Review, 1 Aug. 2014, <https://arkinv.st/37JCLp>.



# Sizing the Opportunity



Improvements in R&D efficiency could **add \$9 trillion** to the market capitalization of therapeutics companies during the next 5 years.



\*Assumes no change in price to sales multiple for the biotech sector, market cap expectations based on expected incremental sales generated from associated R&D spend accounting for likely revenue declines from patent and exclusivity expirations. Based on extensive analysis and reconstruction of historical R&D spend and associated revenue yields. | Forecasts are inherently limited and cannot be relied upon. Source: ARK Investment Management LLC, 2019; Garnier, Jean-Pierre. "Rebuilding the R&D Engine in Big Pharma." Harvard Business Review, 1 Aug. 2014, <https://arkinv.st/37JCLp>.



# Digital Wallets

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According to ARK's research, digital wallets will be valued at a premium to retail banks and, thanks to their low cost of customer acquisition, will offer banking services to low income earners in a way that traditional banks cannot.

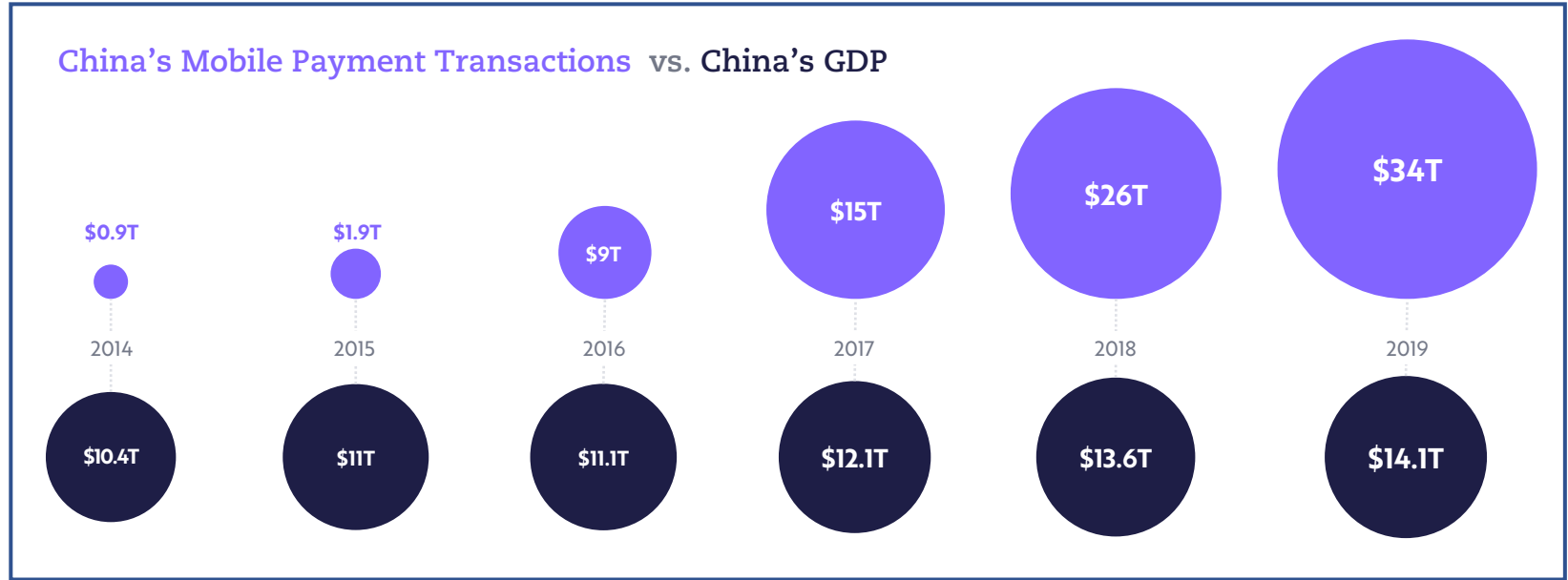
**Given ARK's estimate of 220 million digital wallets in the US by 2024, if every user were to be valued according to the lifetime value of traditional bank customers, the digital wallet opportunity could be worth more than \$800 billion.**





# In China, Mobile Payments Are 2.5x the Size of GDP

Third-party mobile payment transactions in China grew from 10% of GDP in 2014 to nearly 250% in 2019, compounding at a 107% annual growth rate. In ARK's view, global mobile payments will be a multiple of today's \$87 trillion in global GDP.

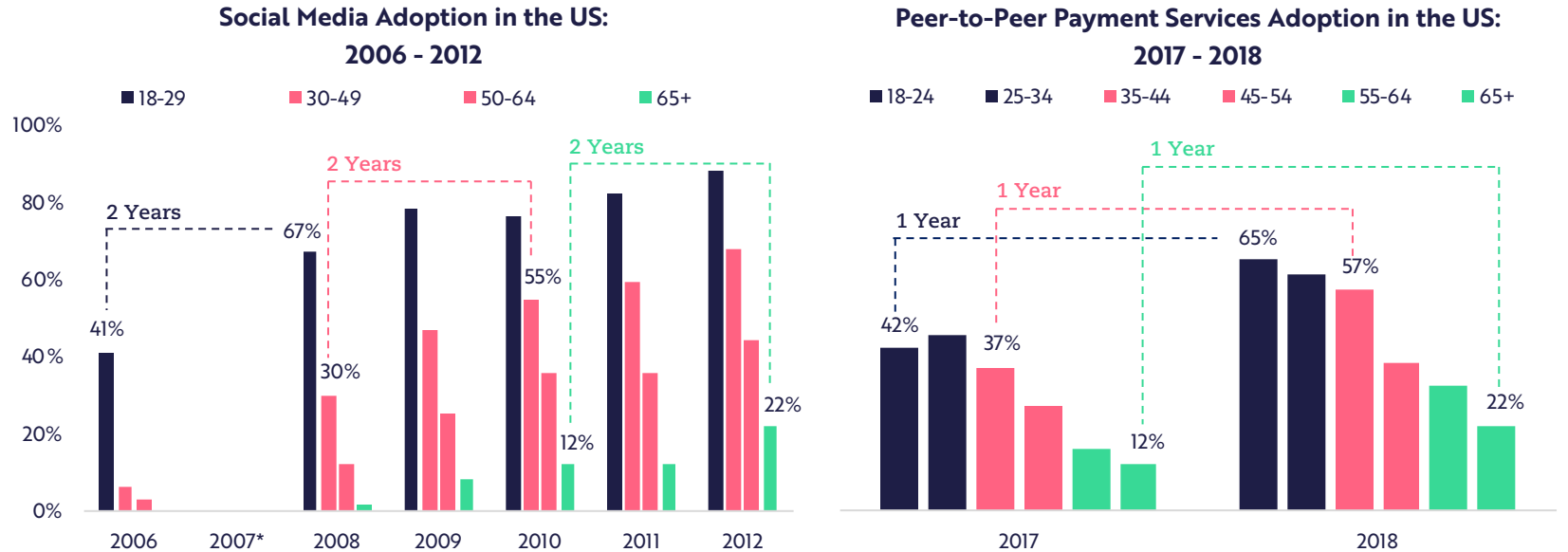


Forecasts are inherently limited and cannot be relied upon. Source: ARK Investment Management LLC, 2019; ARK Estimates; "World Economic Outlook Database, October 2019". IMF.org. International Monetary Fund. 15 October 2019; "GDP - China". World Bank.org. World Bank. 13 December 2019; "China's Third-Party Mobile Payment Market Soared 58.4% in 2018". IResearchChina.com IResearch. 6 May 2019.



# In the US, Digital Wallet Adoption is Occurring 2x Faster Than Social Media Took Off

With network effects that appear stronger than those of social media, digital wallets are penetrating different age groups in the US in half the time that it took social media 10 years ago. Children seem to welcome parents into their payment ecosystems.



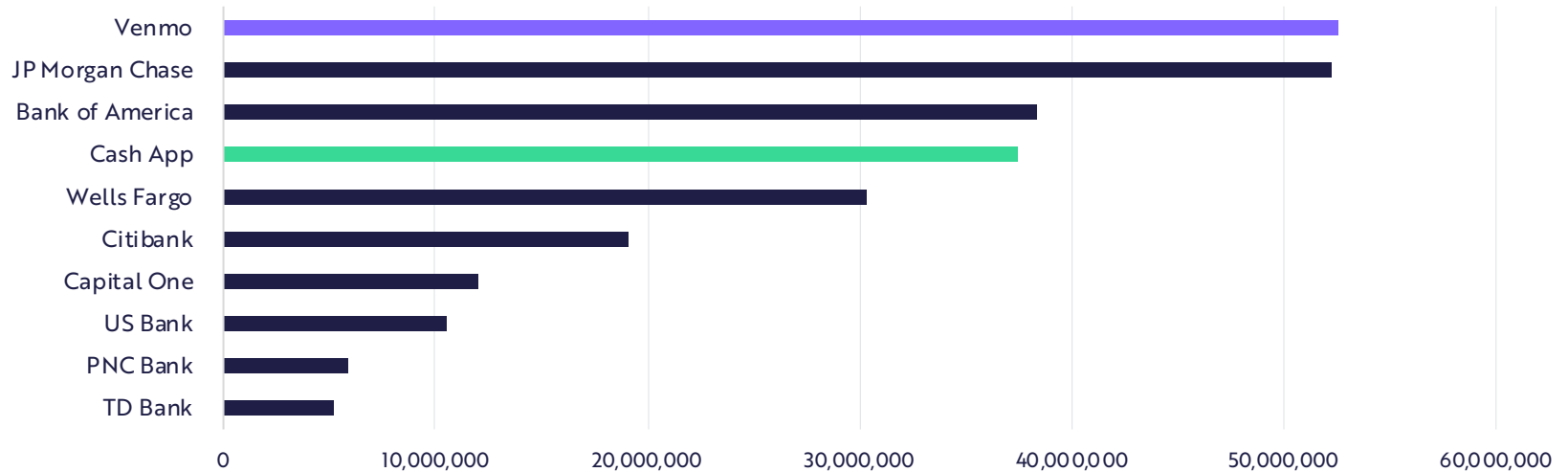
\*Note: Pewresearch.org did not release data on the social media adoption in the US for the year of 2007  
Source: ARK Investment Management LLC, 2019. "2018 TSYS U.S. Consumer Payment Study". TSYS.com TSYS. 18 April 2019; "Social Media Fact Sheet". Pewresearch.org. Pew Research. 12 June 2019.



# Venmo Hosts the Largest Consumer Finance Application in the US

According to ARK's research and with more than 52 million annual active users, PayPal's Venmo has become the largest consumer finance application in the US. Square's Cash App ranks as number four, behind JP Morgan and Bank of America.

**Top 10 Financial Institutions by Number of Active Digital Users (2019)\***



\*Data Source: Estimate of Annual Active Users for Venmo, Bank of America, Cash App, Citibank, Capital One, US Bank, PNC Bank, TD Bank. Estimate of Quarterly Active Users for JPMorgan Chase, Wells Fargo. This is not a recommendation in relation to any named securities and no warranty or guarantee is provided. Any references to particular securities are for illustrative purposes only. Source: ARK Investment Management LLC, 2019. Company information and ARK estimates. Estimate of Annual Active Users for Venmo, Bank of America, Cash App, Citibank, Capital One, US Bank, PNC Bank, TD Bank.

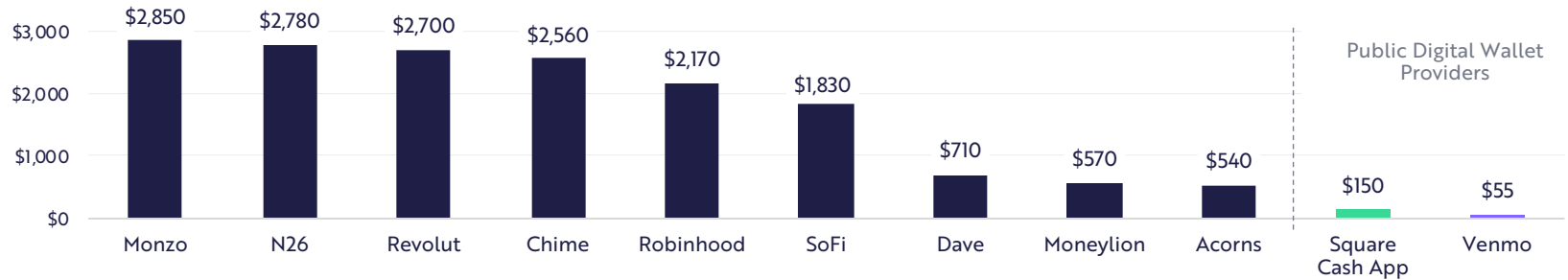


# Digital Wallets Are Valued at a Discount to Banks

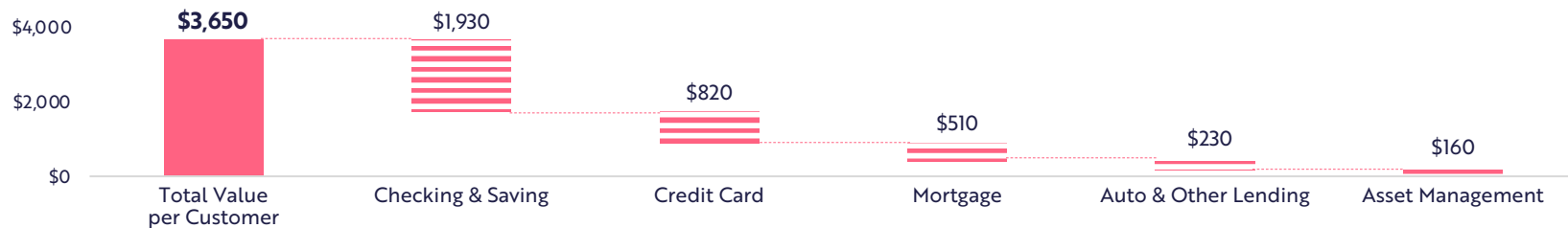
BIG IDEAS 2020

Public markets are valuing digital wallets, such as Square’s Cash App, at a significant discount per user to private fintech valuations. ARK believes that, at maturity, a digital wallet user should be valued at roughly \$3,650, similar to a retail bank customer.

### Valuation Per Active User (USD): Private Fintech Startups vs. Public Digital Wallet Providers



### Valuation Per Customer Across Revenue Segments (USD): Representative Retail Banks in the US



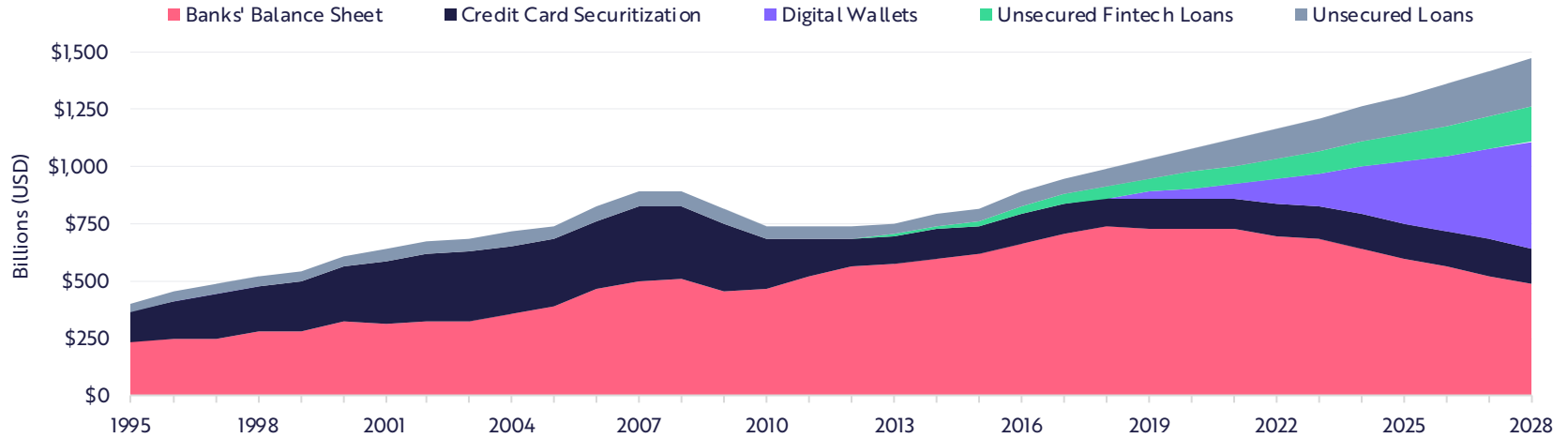
Source: ARK Investment Management LLC, 2019. Company Information, ARK Estimates. For Cash App and Venmo using Square’s and PayPal’s price-to-sales multiple applied to estimated Cash App and Venmo revenue and divided by ARK’s MAU (Monthly Active Users) estimate. For private Fintechs using last valuation divided by ARK’s MAU estimate. | Representative Retail Banks: ARK Estimates based on JP Morgan Chase, Wells Fargo, US Bank, PNC Bank, Bank of America 2018 Annual Reports. This is not a recommendation in relation to any named securities and no warranty or guarantee is provided. Any references to particular securities are for illustrative purposes only.



# Digital Wallets Are Taking Share in the Consumer Credit Market

Fintech companies like LendingClub and Sofi have captured 39% of the unsecured consumer loan market. According to ARK's research, digital wallets will reduce the amount of revolving credit card debt sitting on bank balance sheets from \$740 billion in 2018 to \$483 billion by 2028. As a result, interest income on banks' credit cards is likely to be cut in half during the next five to ten years.

### Total Unsecured Consumer Debt in US



Forecasts are inherently limited and cannot be relied upon. | Source: ARK Investment Management LLC, 2019; "US ABS Issuance and Outstanding," Securities Industry and Financial Markets Association, 6 Dec. 2019, <https://arkinv.st/2sJ7gJf>; "Board of Governors of the Federal Reserve System," The Fed - Consumer Credit - G.19, <https://arkinv.st/2FrB0q6>. This is not a recommendation in relation to any named securities and no warranty or guarantee is provided. Any references to particular securities are for illustrative purposes only.



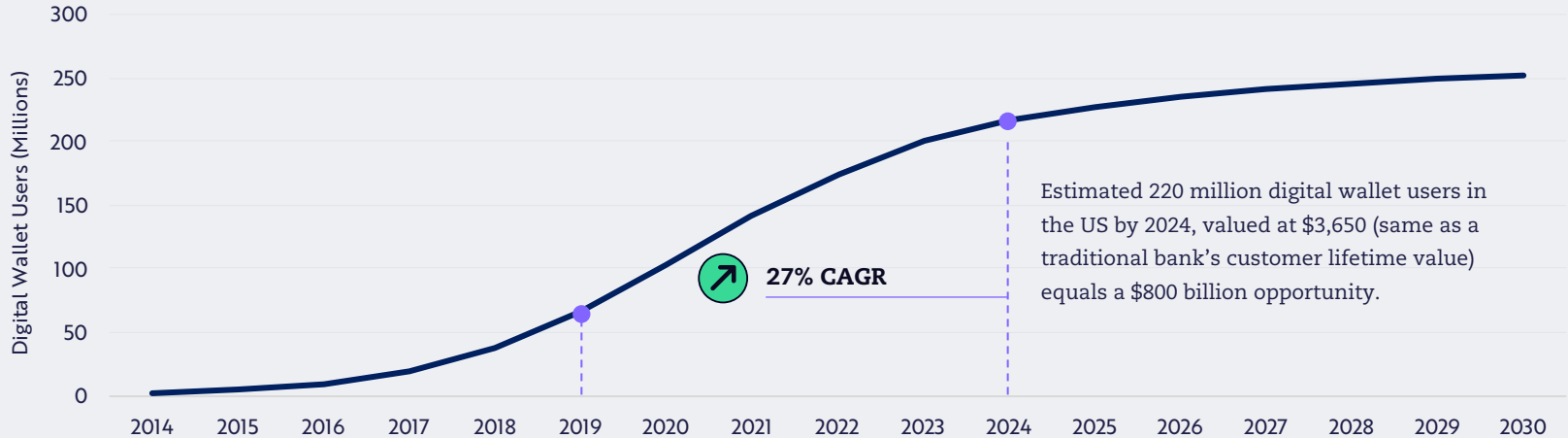


# Sizing the Opportunity



In the US, digital wallets could be valued at **\$800 billion by 2024**, 27x the \$29.5 billion today.

### Digital Wallet Users in the US



Forecasts are inherently limited and cannot be relied upon.  
Source: ARK Investment Management LLC, 2019



# Bitcoin

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Because of bitcoin, we are witnessing a global battle among monetary systems, both sovereign and non-sovereign. As an open, neutral, and permissionless global monetary system with no reliance on the State, bitcoin is in a good position to win this battle.

**If it does, ARK believes the result will be measured in trillions, more than an order of magnitude higher than its \$150 billion network value\* today.**

\*As of publication 01/14/2020

Author: Yassine Elmandjra, ARK Analyst

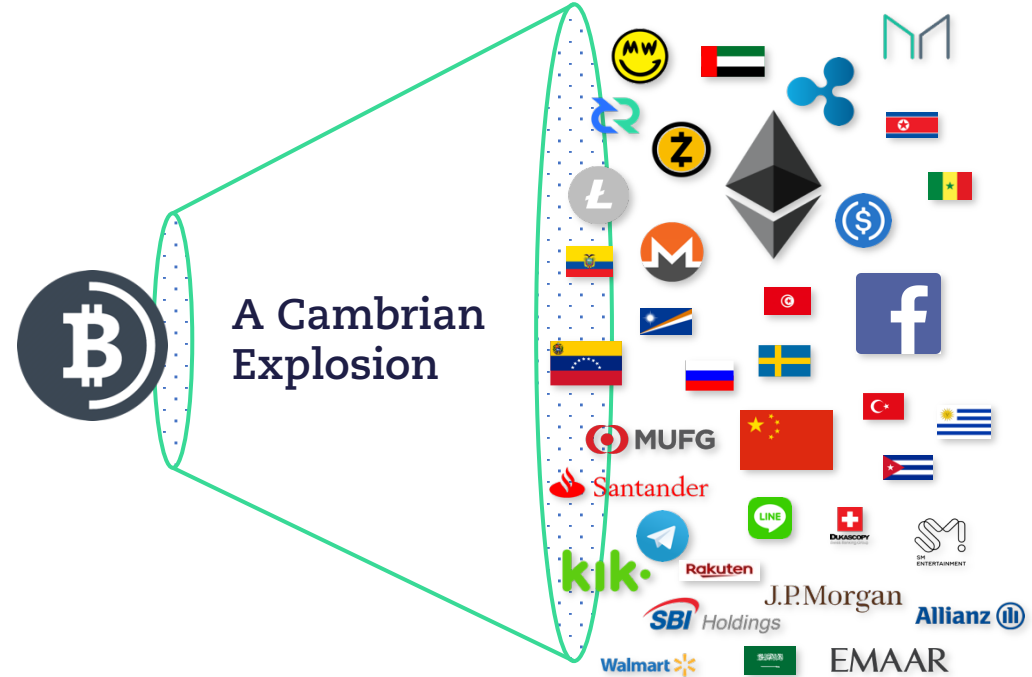




# We Are Witnessing a “Cambrian Explosion” of Monetary Systems

Before the creation of bitcoin, a non-government backed monetary system seemed neither feasible nor imaginable.

Pre-Bitcoin	Post-Bitcoin
An inextricable link between money issuance and the State.	The introduction of money as a private initiative.
The absence of a free market in money.	The rise of digitally native non-sovereign monetary systems.
State exploitation of the physical limitations of non-sovereign money like gold.	Viable forms of self-custody and sovereign wealth ownership enabled by public-key cryptography.

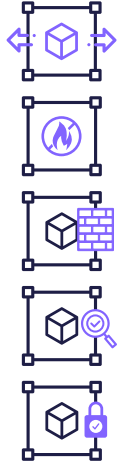


Source: ARK Investment Management LLC, 2019  
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# Today, a Global Battle Among Monetary Systems, Both Sovereign and Non-sovereign, Is Underway

In the long run, ARK expects that the winning monetary systems will ensure:



1. Money will be transferred and stored seamlessly.
2. Money will not be diluted arbitrarily.
3. Money will not be frozen or seized.
4. Money supply will be auditable, and transactions will not be censored.
5. Record of transactions will be secure and immutable.

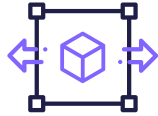


As open, neutral, and permissionless global monetary systems with no reliance on the State, cryptocurrencies appear to be best equipped to win this battle.



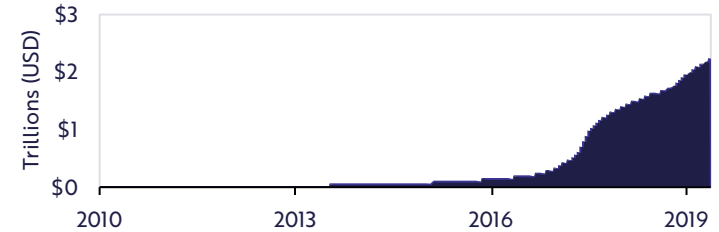
# Among Cryptocurrencies, Bitcoin Is Well Positioned to Satisfy These Assurances

## Assurance 1: Money will be transferred and stored seamlessly.



The Bitcoin network has transferred securely more than \$2 trillion of value. The barriers to transacting on Bitcoin are low, the only requirement being possession of a private key.

### Adjusted Cumulative Bitcoin Transactions Volume

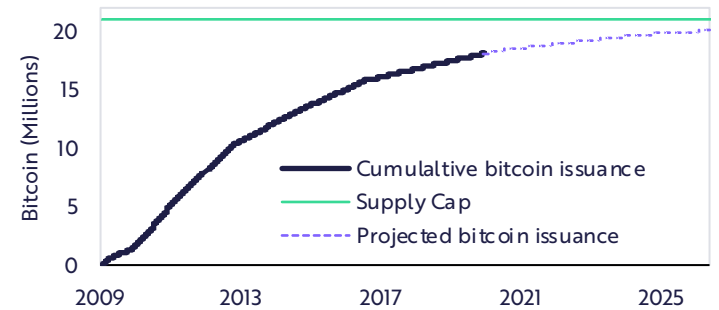


## Assurance 2: Money will not be diluted arbitrarily.



All units of bitcoin have been created according to a mathematically metered, predictable, and predefined schedule. The supply of bitcoin is scarce, capped at 21 million units. Approximately 18 million units have been created with the current issuance growth rate set to halve in May 2020.

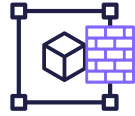
### Bitcoin's Monetary Policy





# Among Cryptocurrencies, Bitcoin Is Well Positioned to Satisfy These Assurances | CONT.

## Assurance 3: Money will not be frozen or seized.



Bitcoin combines elliptic curve cryptography and secure custody to enable the strongest form of jurisdiction-agnostic property rights.

## Assurance 4: Money supply will be auditable.



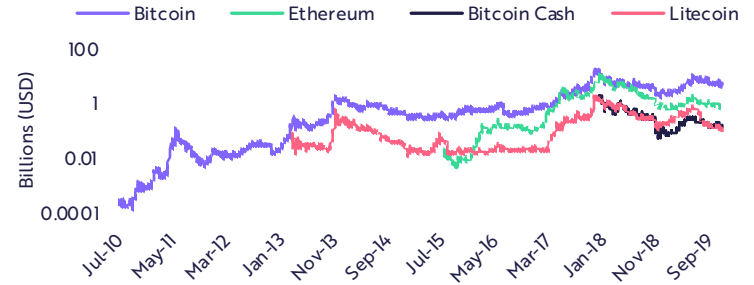
By running a full node, users are free to validate transactions and audit supply. Decision-making in Bitcoin is not subject to a centralized authority: anyone can make a bitcoin transaction permissionlessly.

## Assurance 5: Record of transactions will be secure and immutable.



Bitcoin's annual miner revenue, or ledger costliness\*, is the highest of any cryptonetwork, surpassing \$5 billion in 2019 and making up roughly 80% of total miner revenue in 2019, as shown on the right. Bitcoin recipients can have high confidence that, once embedded in a few blocks, a transaction is unlikely to be reversed.

Annualized Miner Revenue Across Cryptocurrencies






\*The term "ledger costliness" refers to the amount of compensation miners receive per unit of time. Source: ARK Investment Management LLC, 2019; Based on data sourced from: "Network Data Charts." Coin Metrics, <https://arkinvt.st/37tGseJ>; Carter, Nic. Medium, 22 July 2019, <https://arkinvt.st/36OUw2x>.



# Bitcoin Is Gaining Credibility In the Financial Community



Entity	Market Validation
 CAMBRIDGE ASSOCIATES	Portfolio Allocation: Cambridge Associates recommends that institutional investors begin exploring cryptoassets, citing a likely rise in institutional investor exposure.
	Custody: Institutional appetite has fueled the demand for regulated custodial services, with institutions like Fidelity seeking to meet that demand.
<b>Bakkt</b>	Price Discovery and Market Infrastructure: Bakkt's physically delivered futures contract now serves as a benchmark determined by a trusted price discovery process upon which institutional investors can rely.
 Square	Support for Open Source Development: Square launched the first open source Bitcoin initiative, potentially a precursor of open source development from other institutions.

Source: ARK Investment Management LLC, 2019; "Latest Research & Perspectives." Cambridge Associates, Feb. 2019, <https://arkinv.st/359leRH>; Fidelity Digital. "Custody in the Age of Digital Assets." Medium, Medium, 31 Jan. 2019, <https://arkinv.st/36bzk6p>; Bakkt. "We Have Liftoff: a Milestone for the Industry." Medium, Bakkt Blog, 25 Sept. 2019, <https://arkinv.st/2tdbmZY>; De, Nikhilesh. "Square Is Hiring New Crypto Engineers - And It Wants to Pay Them in Bitcoin." CoinDesk, 20 Mar. 2019, <https://arkinv.st/36bie8t>.

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# Sizing the Opportunity



## Currency Demonetization:

Bitcoin as a potential medium of exchange and catalyst for currency demonetization could evolve quickly in emerging markets.

## Digital Gold:

Bitcoin improves upon gold's limitations as a store of value: it is highly portable, strictly scarce, and publicly auditable.

## Protection Utility:

A sensible allocation to bitcoin as protection against asset seizure should approximate the probability of an asset seizure during an individual's lifetime.

### Estimated Future Network Value\*

**\$40 trillion x 5%**

Sum of M2\*\*  
Outside of  
Top 4 Countries      Market Share

**\$9 trillion x 15%**

Gold      P (Bitcoin  
Market Cap.      replacing Gold)

**\$46 trillion x 5%**

Global Wealth      P (Asset Seizure  
of HNWI\*\*\*      over 50 years)

**\$1.1 Trillion**

**\$800 Billion**

**\$1.3 Trillion**

\*Assumes a five-year takeover time, 10% required return, and 9% dilution. Dilution is defined as Bitcoin's inflation rate over the next 5 years consistent with its predetermined supply schedule.  
\*\*M2 is a measure of the money supply that includes cash, checking deposits, and easily convertible near money. M2 is a broader measure of the money supply than M1, which just include cash and checking deposits.  
\*\*\*HNWI (High Net Worth Individual) is defined as a person with investable assets in excess of \$1 million USD.  
Forecasts are inherently limited and cannot be relied upon. | Source: ARK Investment Management LLC, 2019; "This Time Is Different-Data." Harvard University, 2009, <https://arkinv.st/36de9Rd>.





# Disclosure



## For more research on disruptive innovation visit [www.ark-invest.com](http://www.ark-invest.com)

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