

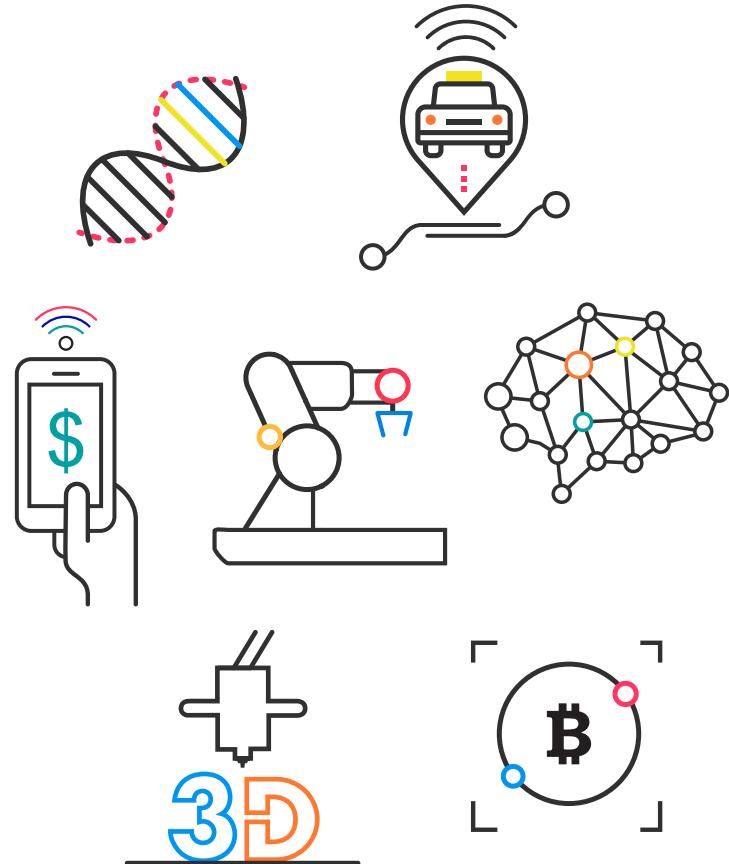
ark-invest.com



ARK INVEST DISRUPTIVE INNOVATION

BIG IDEAS

2017



WELCOME TO INNOVATION!

Rooted in almost 40 years of experience, [ARK Invest](#) aims to identify large-scale investment opportunities resulting from technological change. We believe innovation is key to growth.

From a broad spectrum of disruptive innovations, “Big Ideas” represents our annual breakout of technologies that we believe will accelerate significantly in the months ahead.

Each section provides you with a brief introduction before illustrating the opportunity. At the end of each section we list sources for additional research and insights.



1. Deep Learning



2. Mobility-as-a-Service



3. 3D Printing



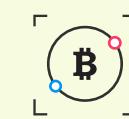
4. CRISPR Genome-Editing



5. Mobile Payments



6. Robotics



7. Cryptoassets

ARK's ANALYST TEAM PRESENTS BIG IDEAS 2017

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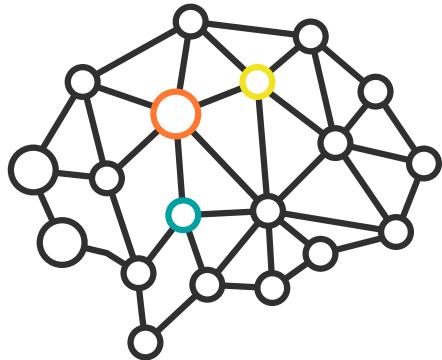
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1. DEEP LEARNING

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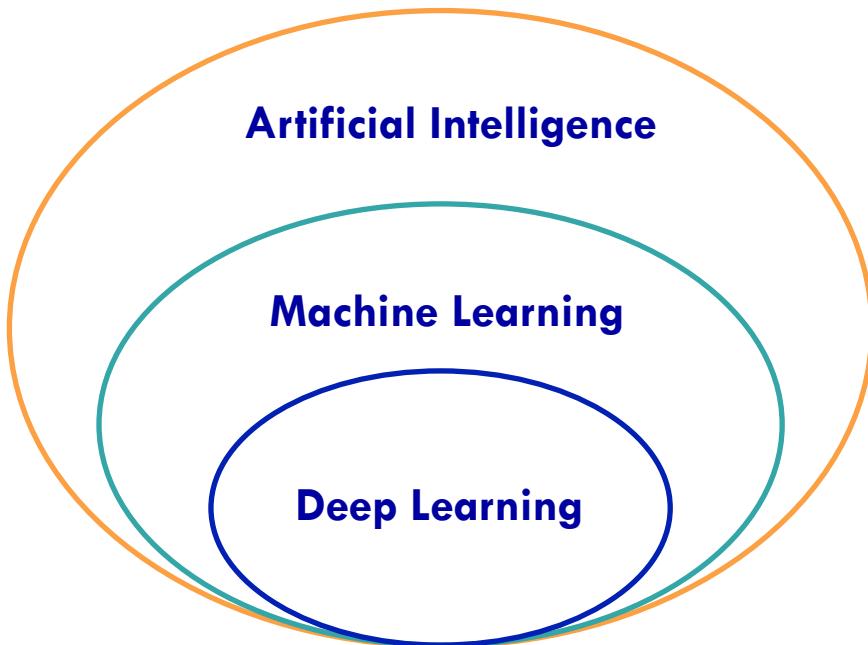


“A breakthrough in machine learning*
would be worth ten Microsofts.”

– Bill Gates (2004)



Artificial Intelligence (AI) vs. Machine Learning vs. Deep Learning

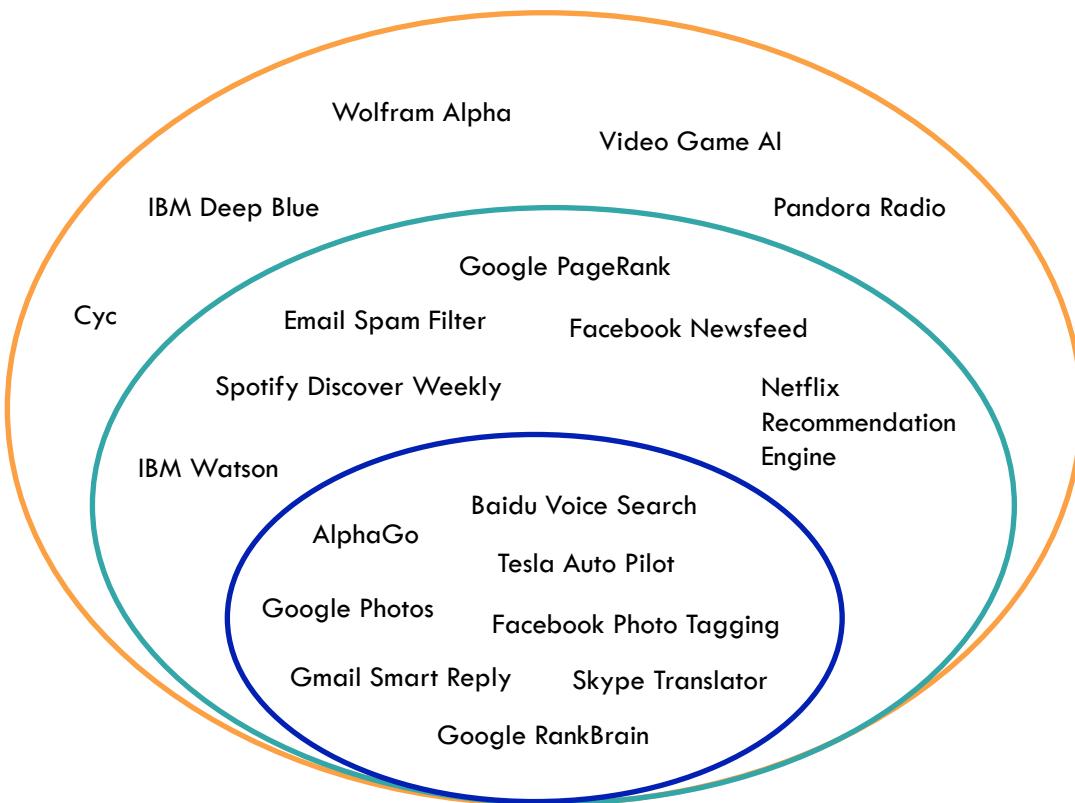


- Classic AI is based on deductive logic.
Rules are based on human ingenuity.
- Machine Learning is based on statistical inference. Rules are inferred from data.
- Deep Learning is a type of Machine Learning modeled after the biological brain.



1. DEEP LEARNING

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Mapping Products to AI

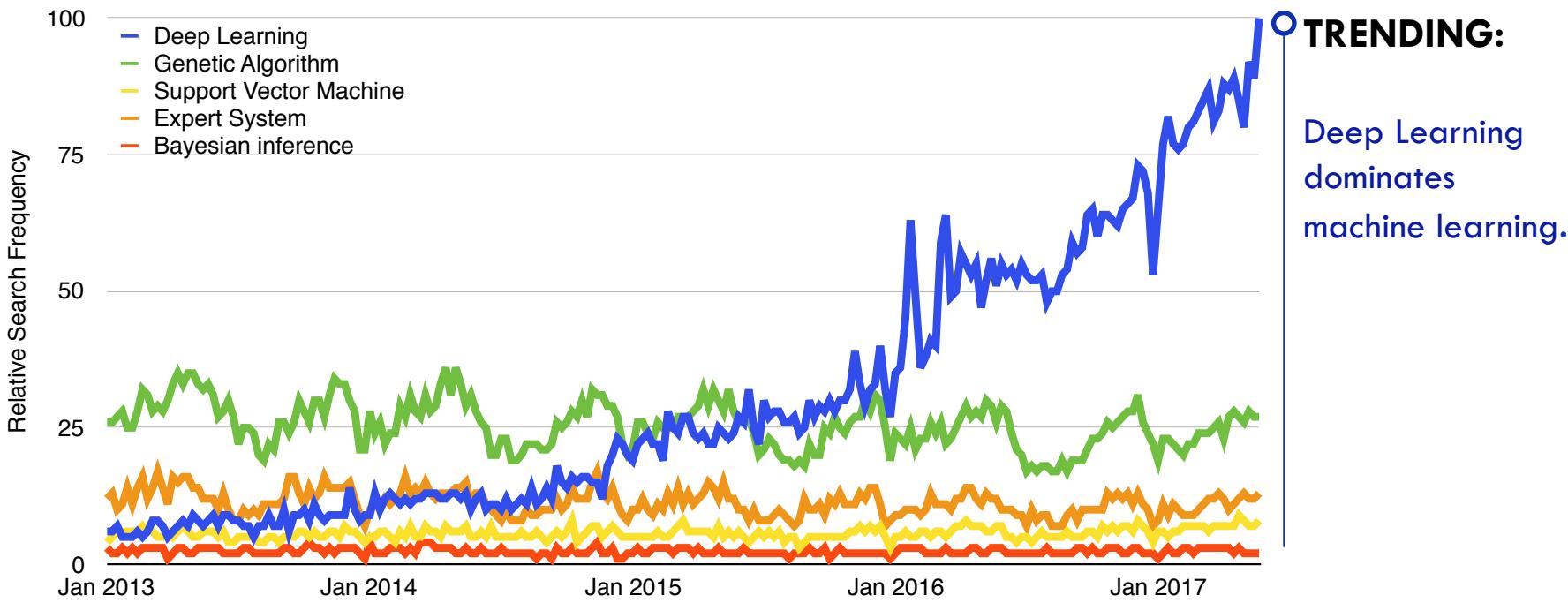
- Artificial Intelligence
- Machine Learning
- Deep Learning



1. DEEP LEARNING

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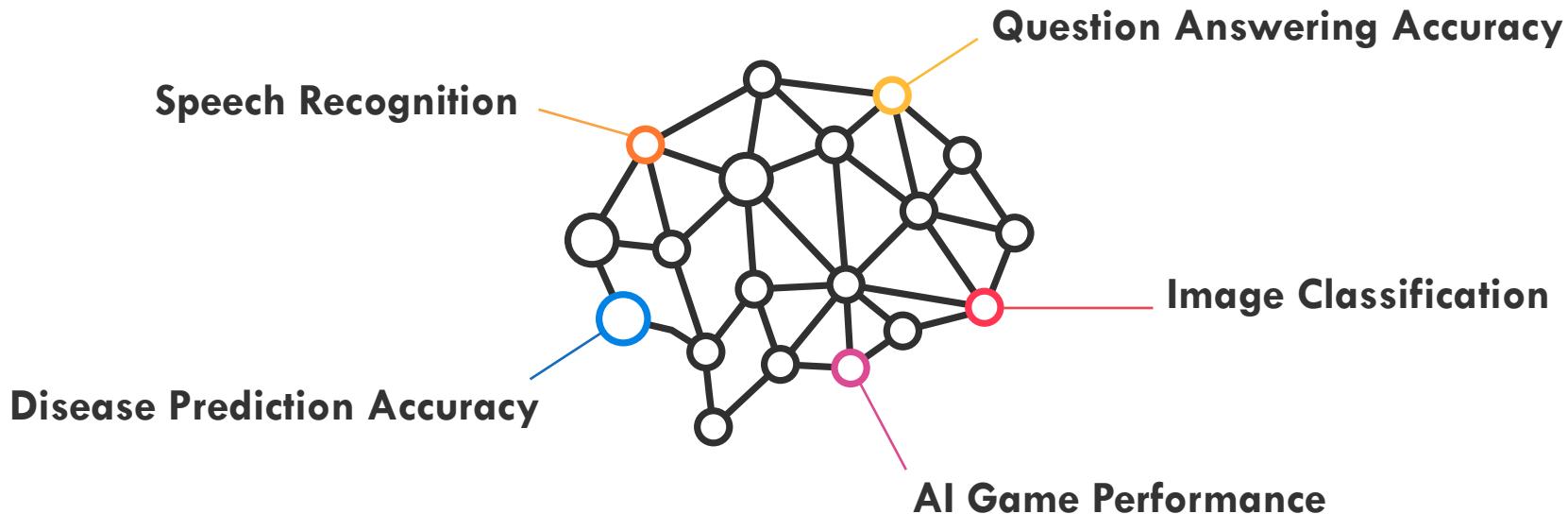
Different Machine Learning Algorithms: Google Search Trends



TRENDING:
Deep Learning
dominates
machine learning.



Recent Deep Learning Breakthroughs

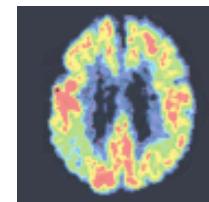
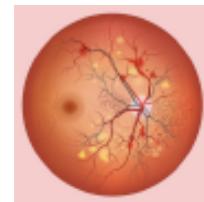
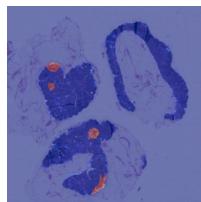




1. DEEP LEARNING

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Example: Deep Learning Is Transforming Medical Imaging



Lung Legions

Breast Cancer

Skin Cancer

Diabetic
Retinopathy

Alzheimer's
Disease

Global Cases
Per Year

1.8M

1.7M

2.5M

93M

44M

Diagnostic Accuracy
with Deep Learning

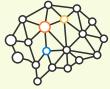
97%

97%

72%

95%

99%



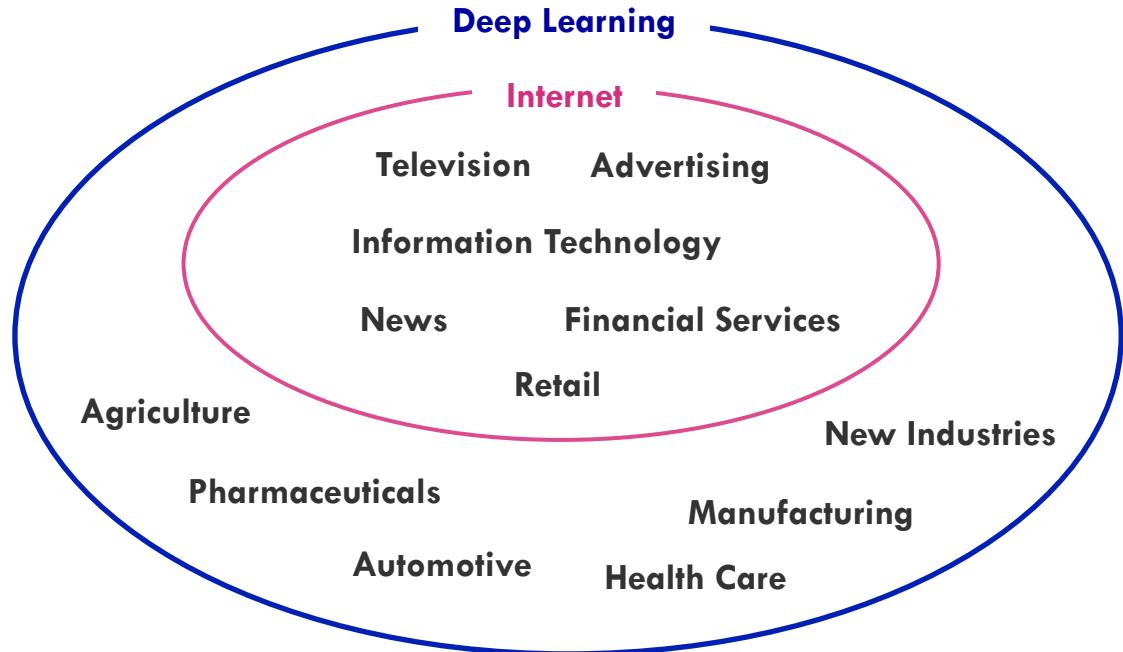
1. DEEP LEARNING

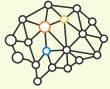
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SIZING THE OPPORTUNITY

**Relative to the internet,
Deep Learning could
impact more sectors,
causing more profound
disruptive innovations.**





SIZING THE OPPORTUNITY

How impactful was the internet?

- 1996 Internet companies made up 0% of the S&P 500
- 2016 Internet companies made up 9% of the S&P 500

→ **This Foundational Technology Took 9% Share In 20 Years**



1. DEEP LEARNING

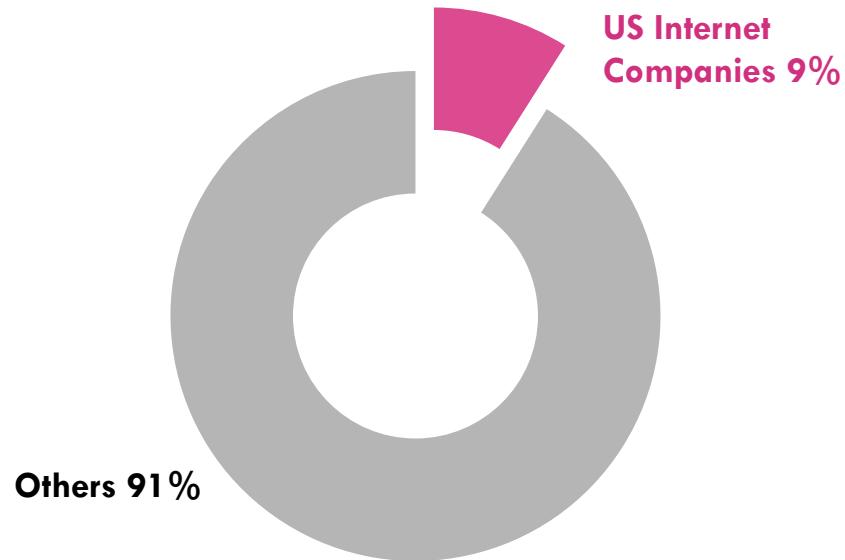
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SIZING THE OPPORTUNITY

S&P 500 Market Cap Created by The Internet

Company	Market Cap (\$B)
Alphabet	\$541
Amazon	\$401
Facebook	\$370
Cisco	\$150
Netflix	\$52
Salesforce	\$51
Yahoo	\$40
Ebay	\$34
Akamai	\$12
Juniper Networks	\$11
Verisign	\$9
F5 Networks	\$9
Total	\$1,680
S&P 500 Market Cap	\$19,622
New Market Cap Creation From The Internet	8.6%

Pure Internet Companies As A Percent of S&P 500



Source: ARK investment Management LLC, as of December 2016



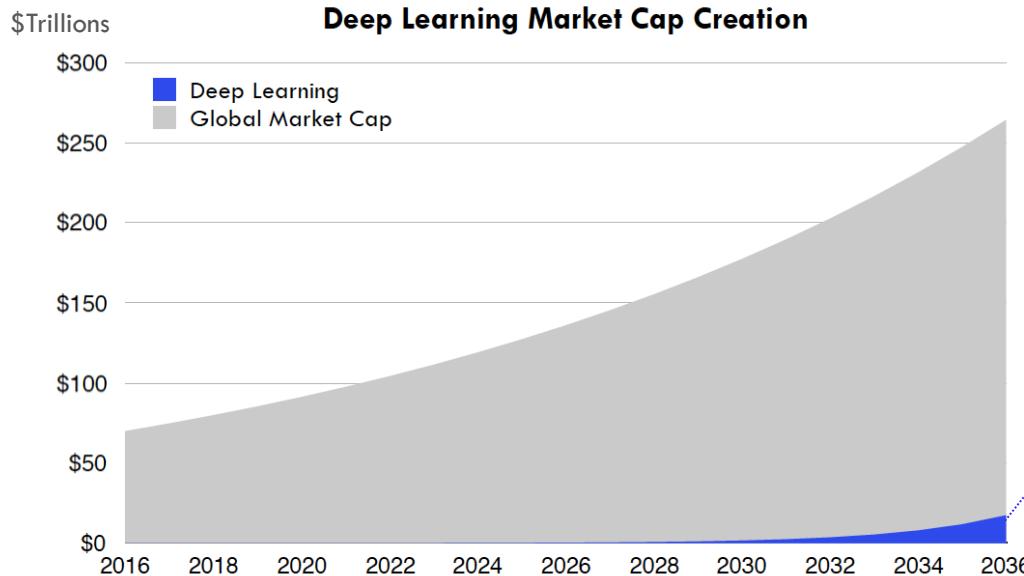
1. DEEP LEARNING

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Globally, Deep Learning Could Approach A \$17 Trillion Market Cap in 20 Years



...creating the equivalent
of 35x Amazon's.

amazon

Source: ARK Investment Management LLC, as of December 2017 Deep learning penetration adjusted for global market cap, assuming 6.9% historical growth rate of global equities, 6.6% deep learning share in 20 years.

Source: ARK Investment Management LLC, as of June 2017



Additional Research:



WHITE PAPER

Deep Learning—A Revolution in Artificial Intelligence

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James Wang
Analyst

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2. MOBILITY-AS-A-SERVICE

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“The removal of the driver is arguably the most significant and transformative innovation ever faced by the automotive industry.”

— “*The Future of Autonomous Cars*”, Berg Insights (2016)

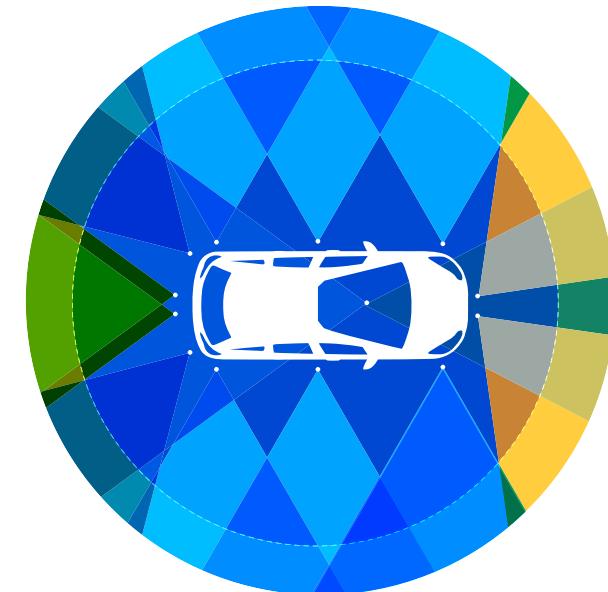


2. MOBILITY-AS-A-SERVICE

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ARK expects that before 2020 fully autonomous vehicles will become commercially available, enabling the rapid rise and growth of autonomous taxi networks.

- These networks should decrease the cost and inconvenience of point-to-point mobility dramatically, spurring a transformative boost in economic productivity.
- As a result, the traditional automotive industry may be subsumed by Mobility-as-a-Service (MaaS) platforms that could become one of the most valuable investment opportunities in public equity markets.



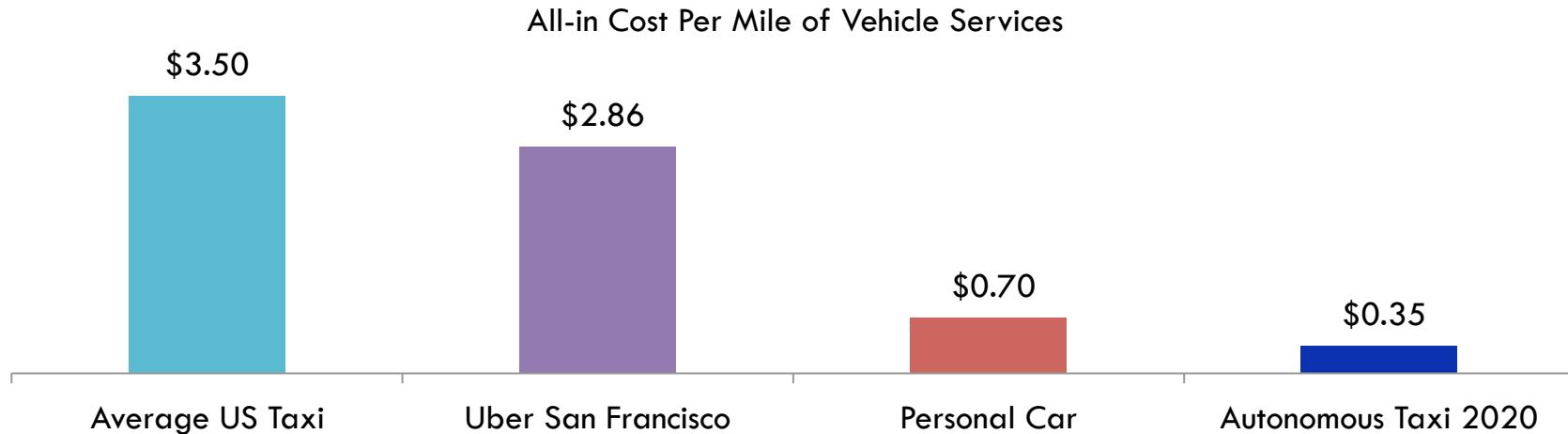
Source: ARK Investment Management LLC



2. MOBILITY-AS-A-SERVICE

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ARK's research shows that the price of autonomous travel will be roughly half the cost of driving a personal car today.



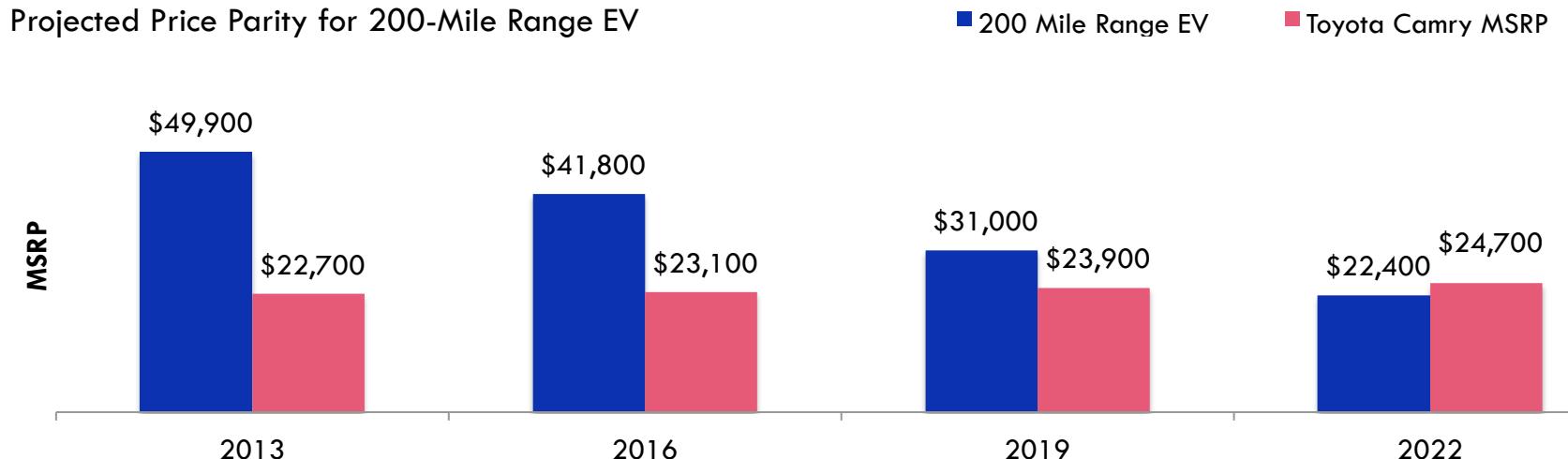
- These compelling economics will drive consumer adoption
- Autonomous taxis should become the dominant form of vehicle transportation in urban areas



2. MOBILITY-AS-A-SERVICE

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Because battery costs have declined faster than most analysts anticipated, ARK foresees a wholesale shift to electric vehicles (EVs). By 2022 EVs should be cheaper than comparable gas-powered cars.



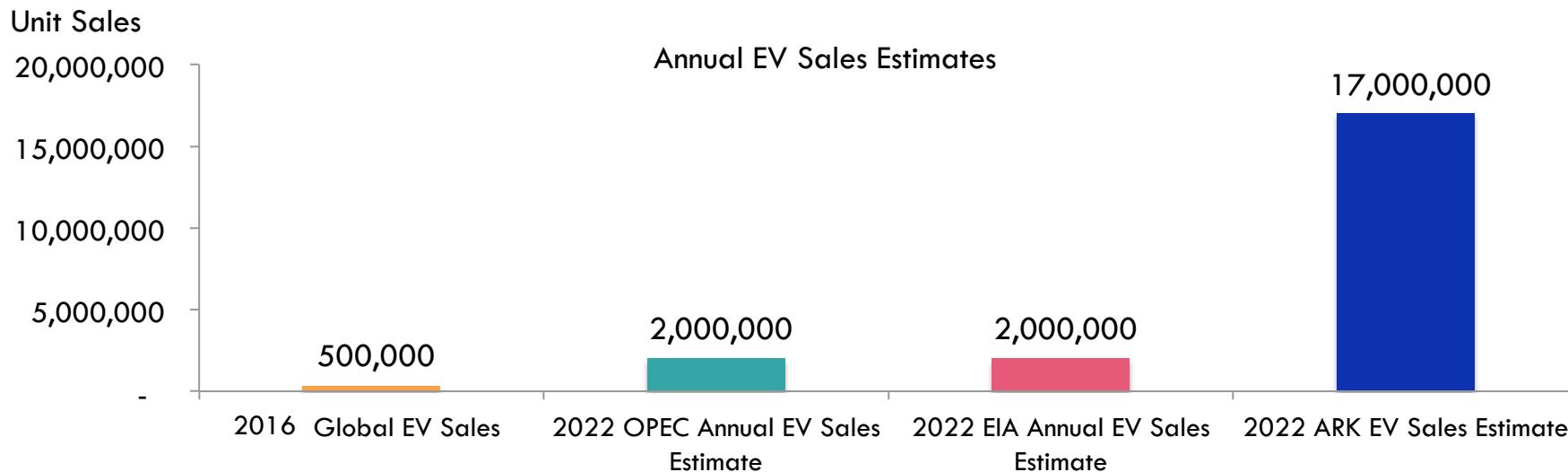
ARK's expectation for EV MSRP (manufacturer's suggested retail price) parity is largely based on decreasing lithium-ion battery costs. Other factors could influence MSRP. The MSRP prices shown do not include any government subsidies.



2. MOBILITY-AS-A-SERVICE

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Based on ARK's Research, The Demand For EVs Will Be Orders Of Magnitude Higher Than Current Consensus Forecasts.



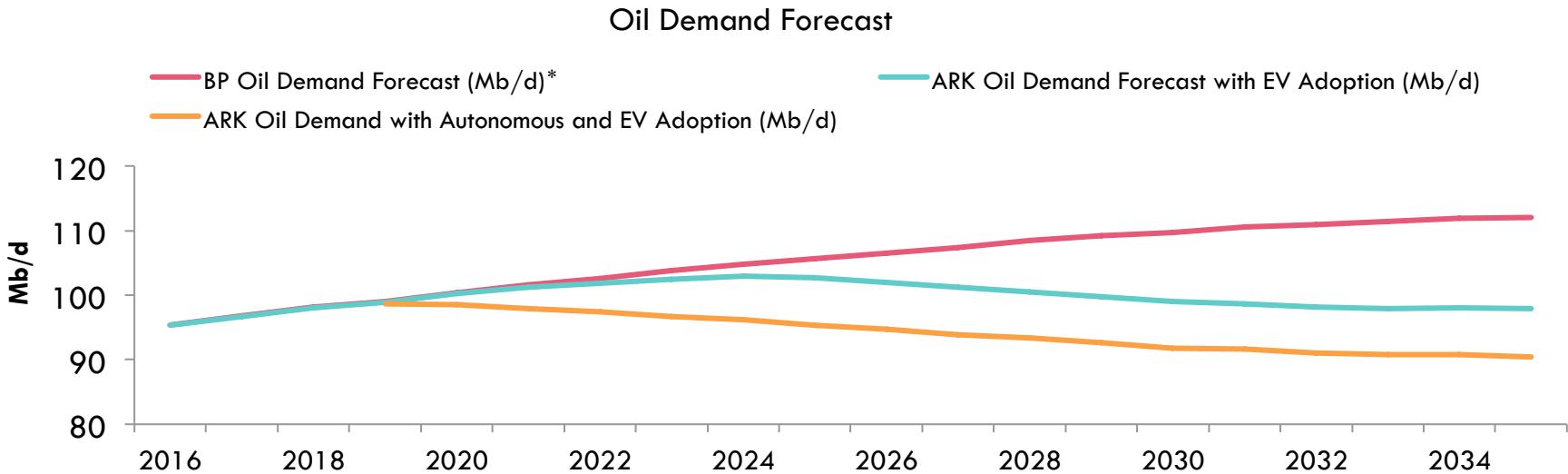


2. MOBILITY-AS-A-SERVICE

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What will happen to oil prices?

EVs and autonomous technology could cause oil demand to peak before the end of the decade.



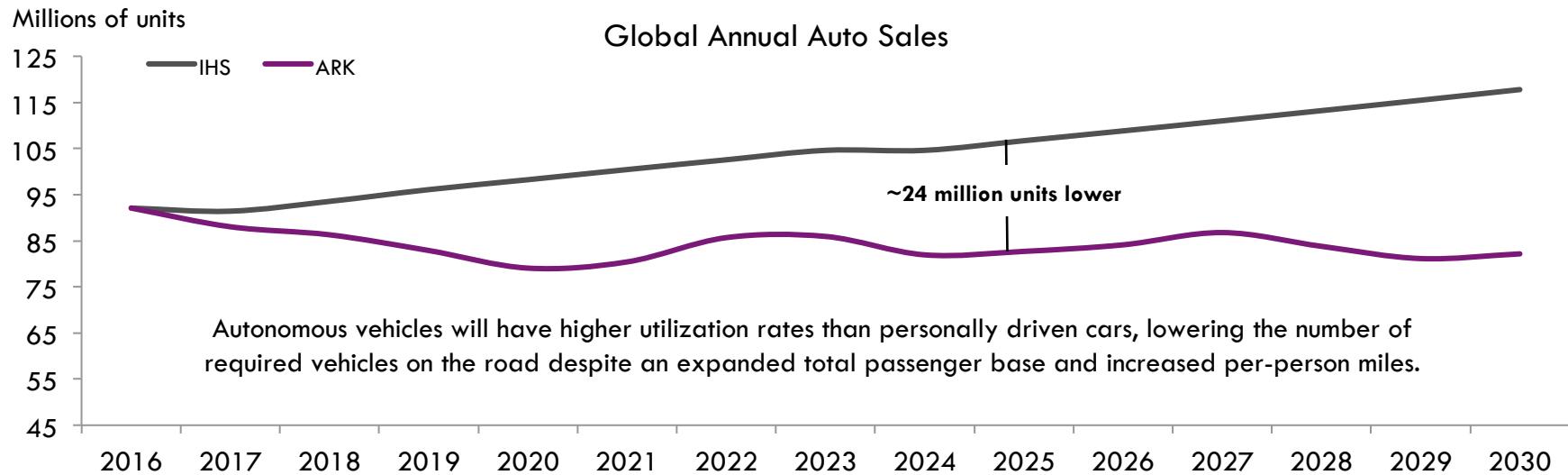


2. MOBILITY-AS-A-SERVICE

ARK INVEST | BIG IDEAS 2017

What will happen to auto sales?

ARK expects auto sales to be much lower than anticipated, thanks to autonomous taxis.



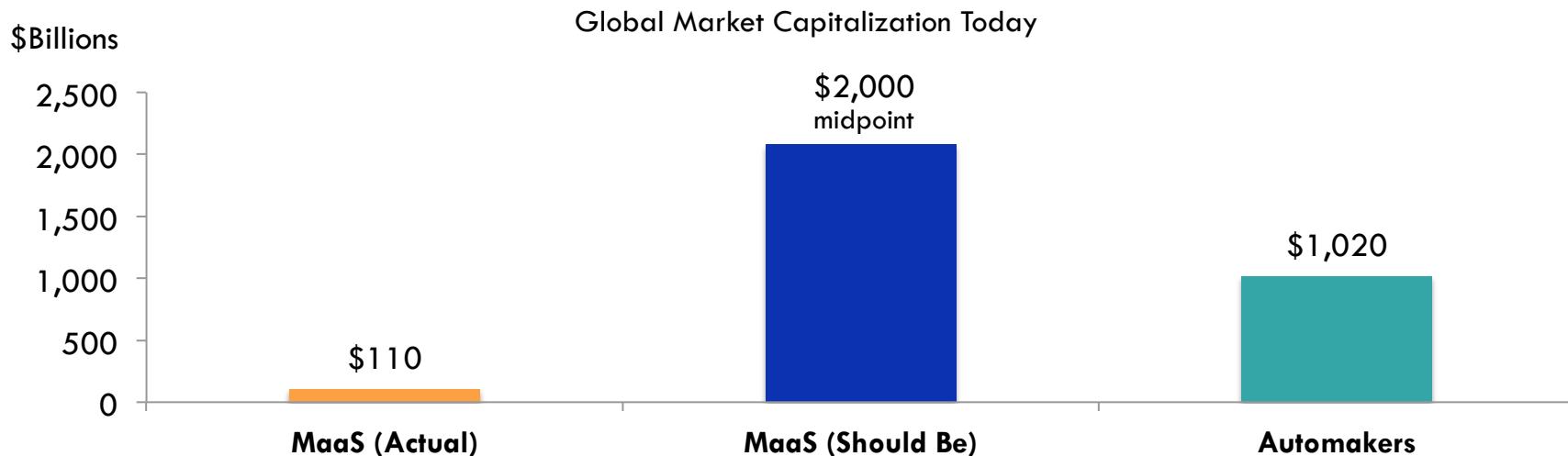


2. MOBILITY-AS-A-SERVICE

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SIZING THE OPPORTUNITY

Based on ARK's research, mobility-as-a-service (MaaS) should be valued at \$1-3 trillion today.



Source: ARK Investment Management LLC



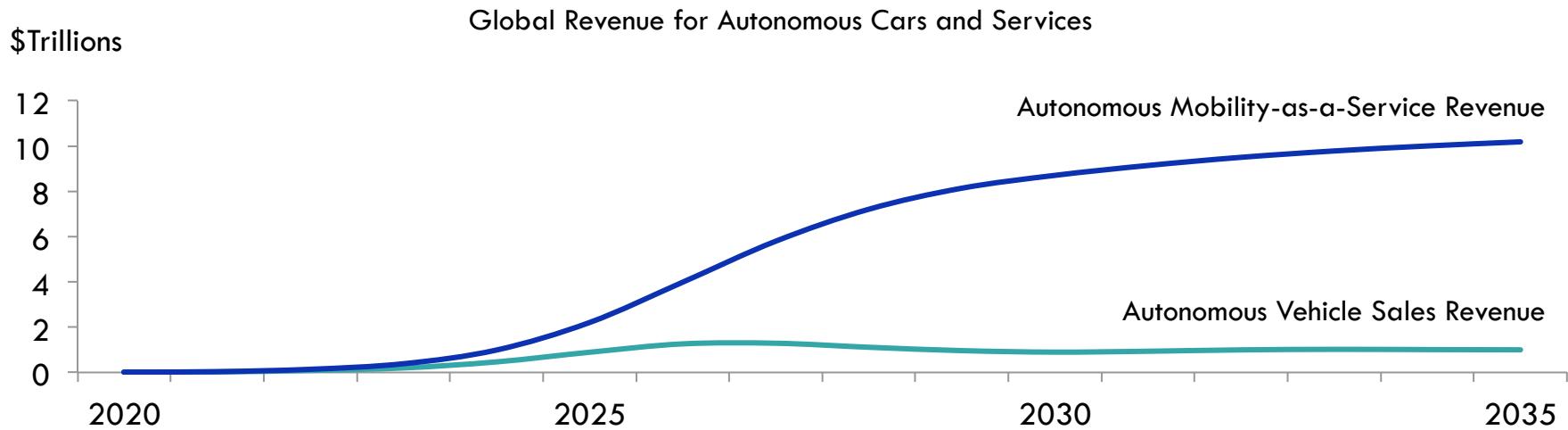
2. MOBILITY-AS-A-SERVICE

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SIZING THE OPPORTUNITY

ARK estimates autonomous MaaS will reach \$10 trillion in gross sales by the early 2030s, 20% of which could accrue to service operators.



Source: ARK Investment Management LLC



2. MOBILITY-AS-A-SERVICE

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Additional Research:



WHITE PAPER

Mobility-as-a-Service: Why Self-Driving Cars Could Change Everything

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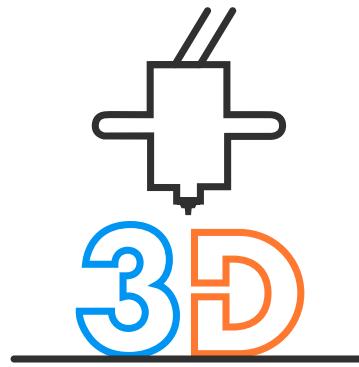
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3. 3D PRINTING

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“3D printing is already shaking our age-old notions of what can and can't be made.”

– Hod Lipson, Director of Columbia University's Creative Machines Lab (2013)



3. 3D PRINTING

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3D printing has the potential to revolutionize traditional manufacturing.

By building objects layer-by-layer, instead of removing material from a larger block or using a mold, 3D printing offers a range of benefits:

- **Shortens design-to-production time**
- **Shifts power to the designers**
- **Creates products with less waste**
- **Enables radically new architectures**
- **Reduces the cost of manufacturing significantly**



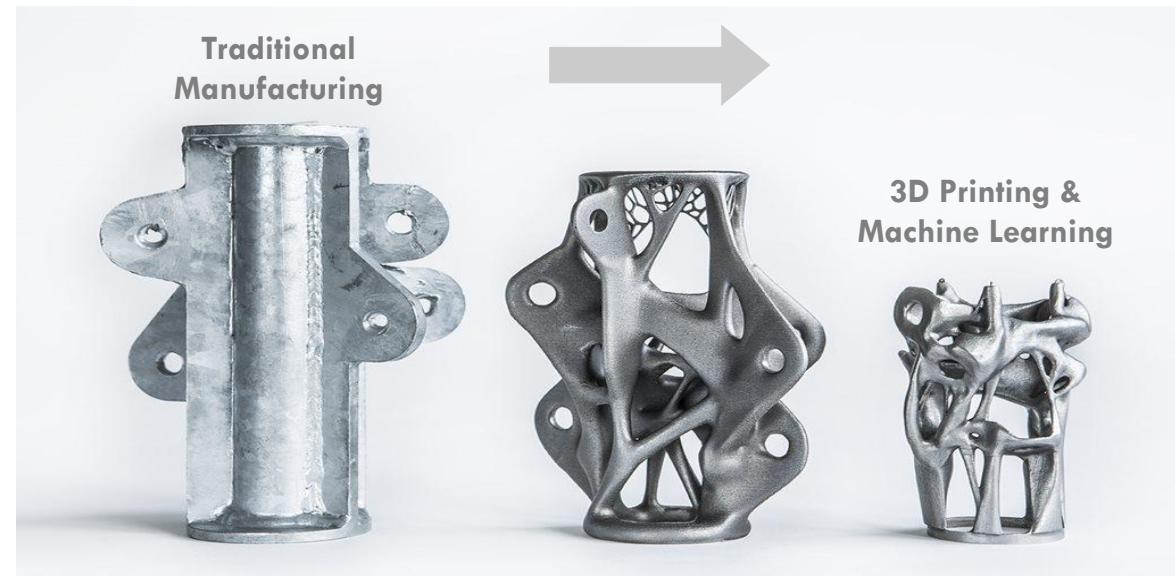


3. 3D PRINTING

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3D printing and machine learning create better designed parts that humans may never would have imagined.

For example, these structural nodes all support the same weight, but the part on the right weighs 75% less and is 50% smaller than the original part on the left.





3. 3D PRINTING

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GE expects additive manufacturing to generate \$1 billion in revenues by 2020, and it expects to save \$3 – 5 billion in costs.

Use Case: Aerospace & Aviation

Proof point: Advanced Turboprop Engine (ATP)

Combustor test schedule reduced from **12 months** to **6 months**

No structural casting

20%
LOWER MISSION
FUEL BURN

5%
WEIGHT
REDUCTION



855 ▶ 12
PARTS



*Sources: <http://www.geglobalresearch.com/innovation/3d-printing-creates-new-parts-aircraft-engines>
https://www.ge.com/investor-relations/sites/default/files/GE%20Additive_Oppenheimer%20Annual%20Industrial%20Growth%20Conference.pdf



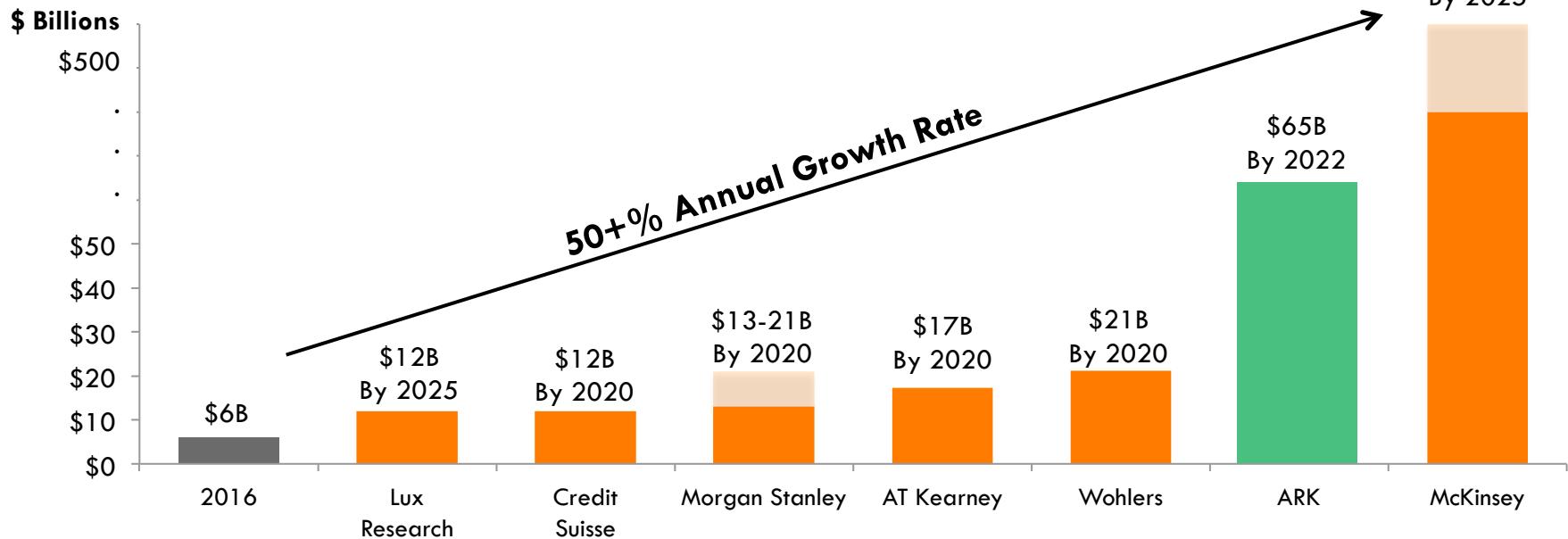
3. 3D PRINTING

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SIZING THE OPPORTUNITY

Global Estimates for 3D Printing Market 2020 to 2025





3. 3D PRINTING

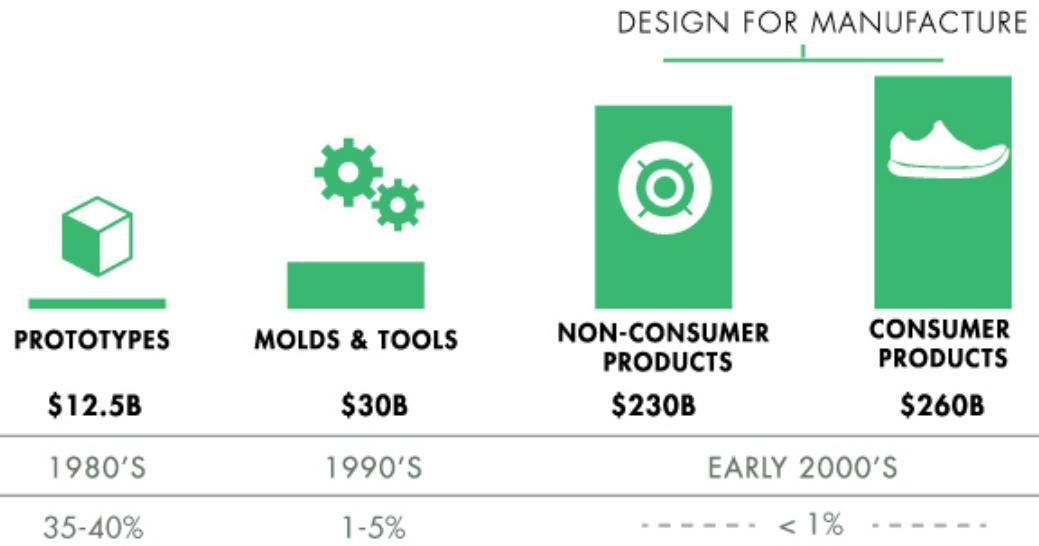
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SIZING THE OPPORTUNITY

The final frontier for 3D printing will be the finished product market.

3D Printing Global Market Penetration:



Source: ARK Investment Management LLC, Data from McKinsey, Fredonia Group, US Congressional Research Service

*Source: ARK Investment Management LLC; <http://www.avplastics.co.uk/3d-printing-history>



3. 3D PRINTING

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Additional Research:



WHITE PAPER

3D Printing: A Disruptive Innovation In Its Infancy

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4. CRISPR GENOME-EDITING

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“The idea of gene correction is not new at all, but before CRISPR it never worked well enough so that people could do it routinely.”

– Carl June, Biologist University of Pennsylvania (2016)



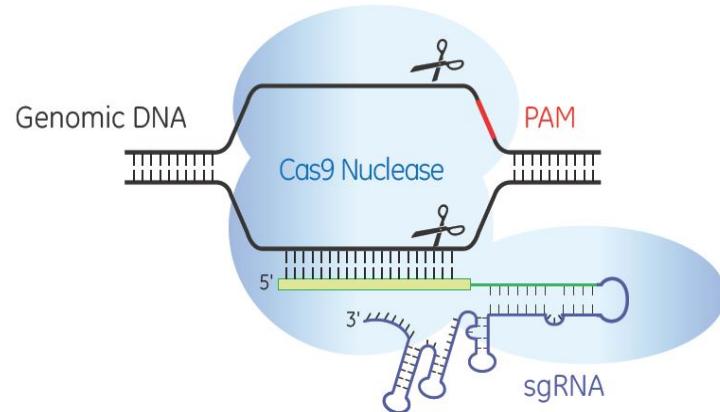
4. CRISPR GENOME-EDITING

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CRISPR is one of the breakthrough technologies of the century and will likely increase the pace of innovation in biotechnology.

Cheap, Easy, and Rapid DNA “Write” Capabilities:

Derived from bacteria,
Clustered Regularly
Interspaced Short
Palindromic Repeats
(CRISPR for short)
is a new genome-editing
platform technology that
can correct mistakes in
the genome.



Previously

1980's	Gene expression manipulated
2001	First whole human genome sequenced
2013	Next generation sequencing platform enabled \$1,000 per genome
2020	Improved sequencing platforms enables \$100 per genome



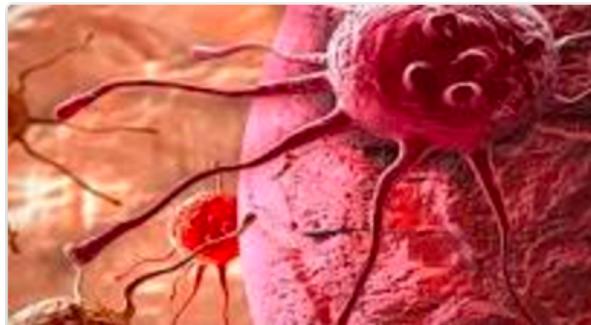
4. CRISPR GENOME-EDITING

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CRISPR technology has emerged as a winner in genome-editing.

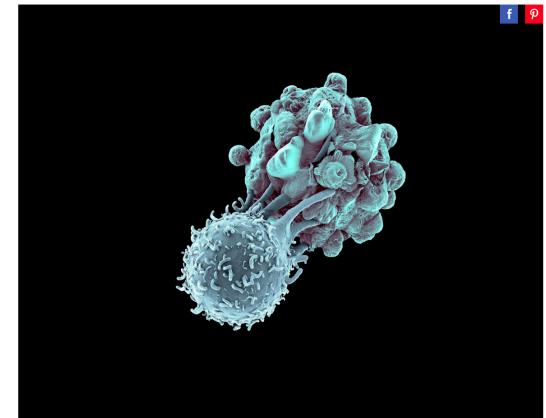


Edible CRISPR Could Replace Antibiotics



CRISPR kills HIV and eats Zika 'like Pac-man'. Its next target? Cancer

CHINA USED CRISPR TO FIGHT CANCER IN A REAL, LIVE HUMAN



Source: Time Magazine, MIT Technology Review, Wired Magazine



4. CRISPR GENOME-EDITING

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Genome-Editing Technologies

	ZFNs ¹	TALENs ²	CRISPR
Year of First Human Cell Modification	2003	2009	2012
Time to Manufacture (days)	22	10	5
Cost (per pair of nucleases)	~\$5,500	~\$360	~\$30
Efficient Editing?	Yes	Yes	Yes

Newer Genome-Editing Technique



CRISPR TECHNOLOGY IS:

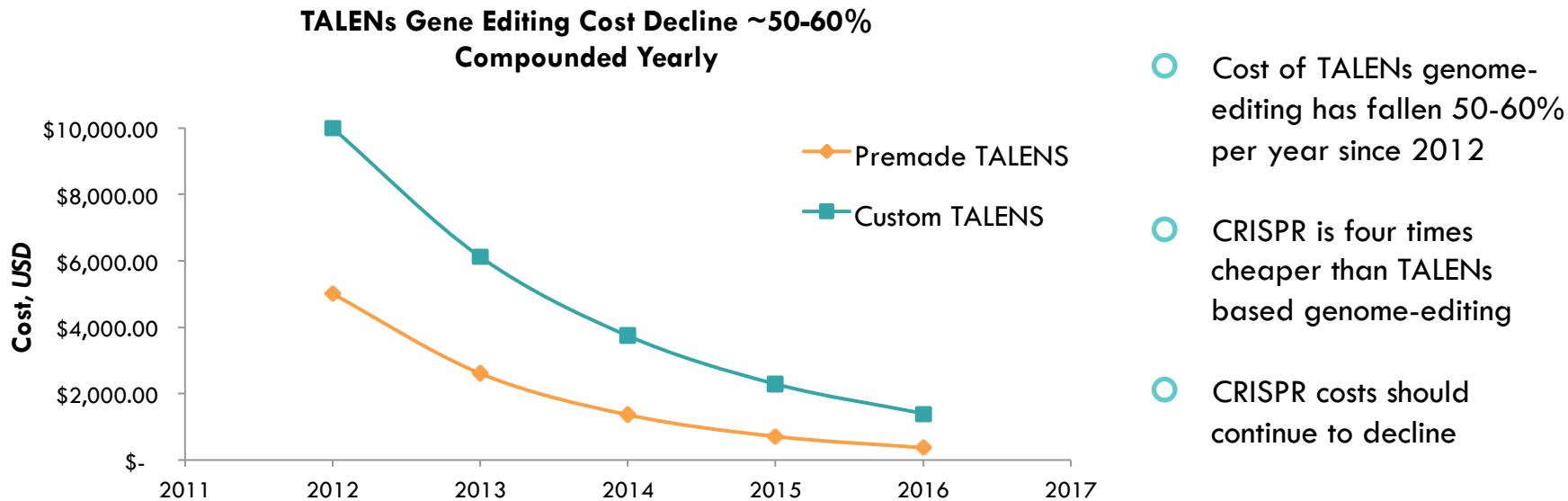
- ✓ Easier to use thanks to simple manufacturing process and faster learning curve.
- ✓ More cost effective as research capacity expands.
- ✓ Comparable to legacy genome-editing technologies in editing efficiencies.



4. CRISPR GENOME-EDITING

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The cost of genome-editing has declined by 28x-52x* in the last 4 years.



* Subject to pre-made versus custom-made editing reagents



4. CRISPR GENOME-EDITING

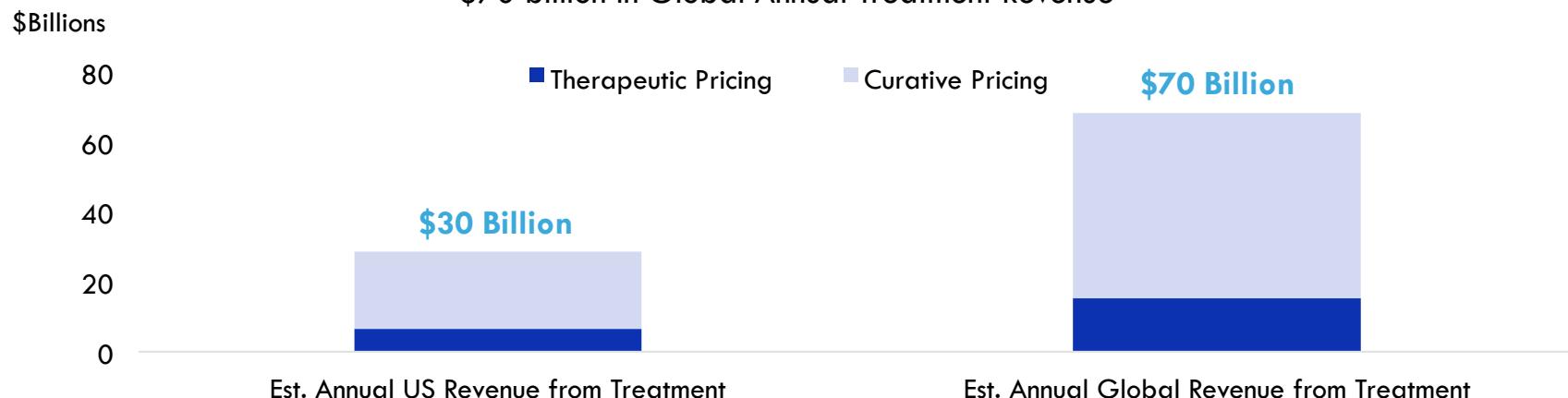
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SIZING THE OPPORTUNITY

CRISPR could address 10,000 monogenic diseases*, only 5% of which are treatable today.

CRISPR Opportunity: Addressing all Monogenic Diseases Could Yield
\$70 billion in Global Annual Treatment Revenue



Source: ARK Investment Management LLC,

Annual revenue if we were able to treat all 10,000 monogenic diseases today (2017) through 2030

*A disease acquired by a single gene mutation

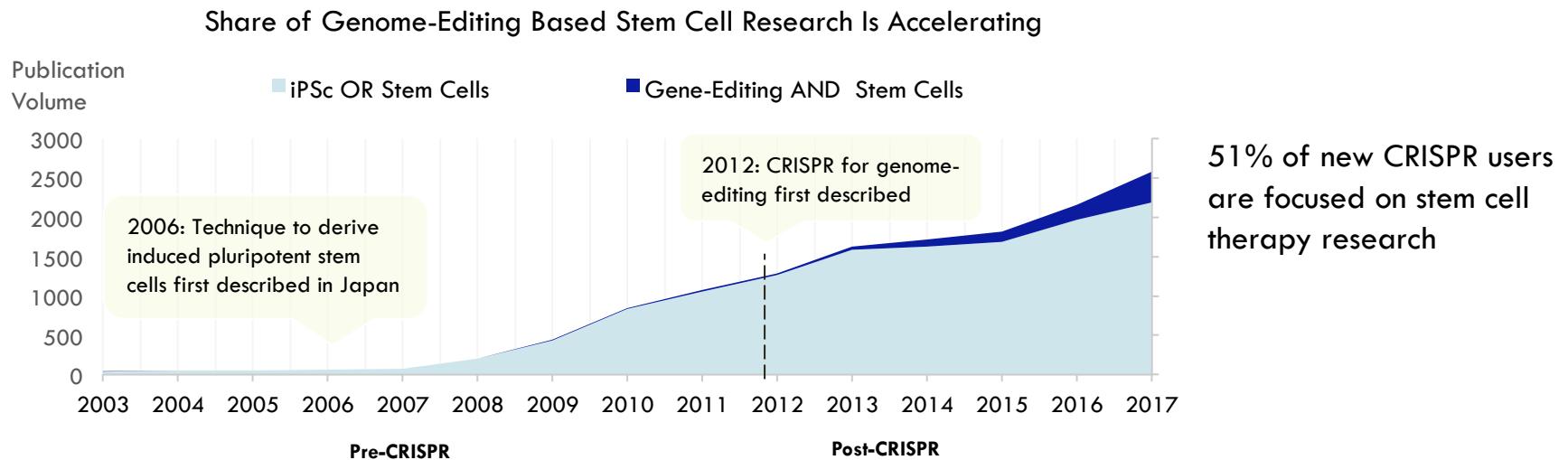


4. CRISPR GENOME-EDITING

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Today, ~18% of publications focused on stem cells involve genome-editing, up from 1% in 2012 when CRISPR was discovered.



Source: ARK Investment Management LLC, Dec. 2016

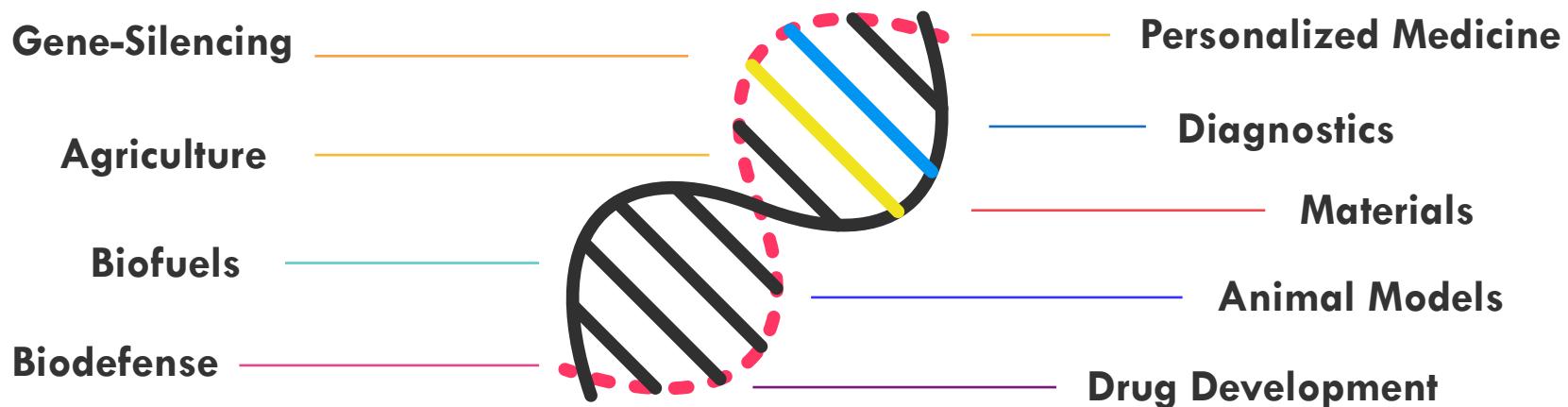


4. CRISPR GENOME-EDITING

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CRISPR Applications Extend Beyond The Therapeutics Space



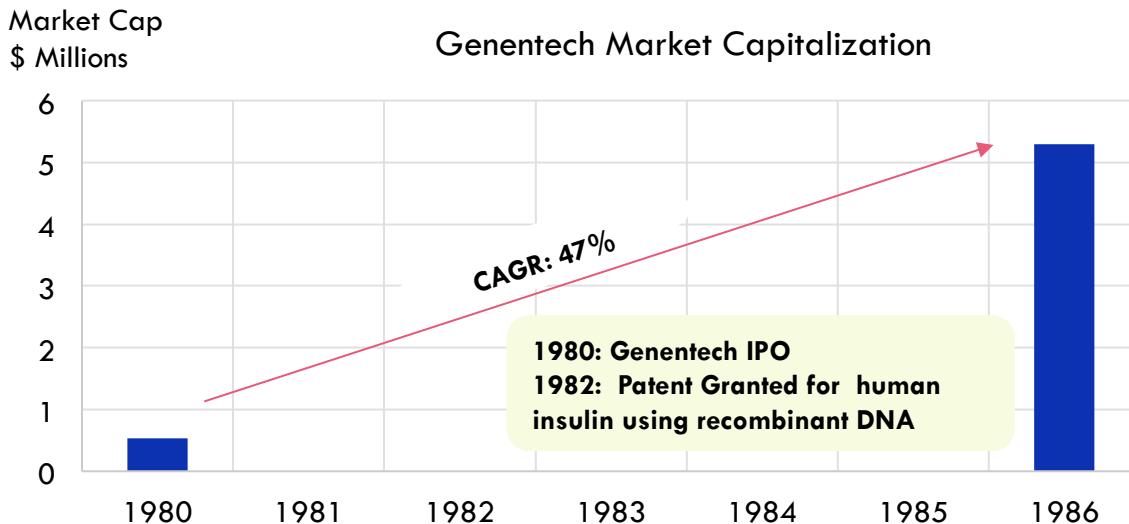


4. CRISPR GENOME-EDITING

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Genentech's market capitalization increased 11-fold in 6 years largely due to its strong IP position for recombinant DNA.



The scope and scalability of CRISPR technology should continue to expand rapidly across different applications, with several companies vying for CRISPR intellectual property rights.



4. CRISPR GENOME-EDITING

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Additional Research:



RESEARCH BLOGS:

The CRISPR Gene Editing Approach to Treating and Curing Diseases



Spell-Checking the Language of Life: CRISPR Gene Editing In Living Animals



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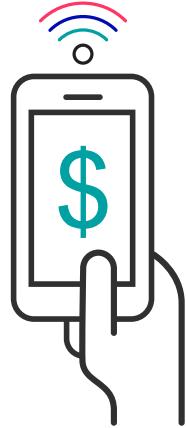


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5. MOBILE PAYMENTS

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“Future of Payments is Mobile.”

– Dan Schulman, CEO PayPal (2016)

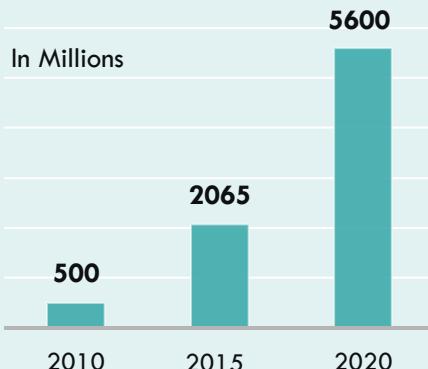


5. MOBILE PAYMENTS

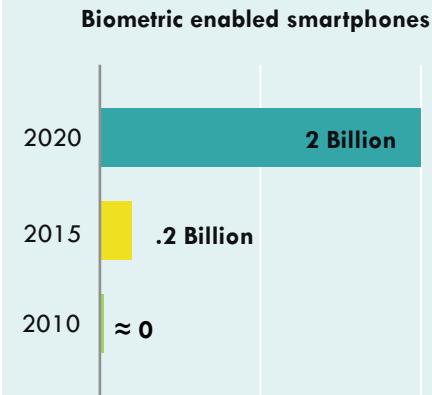
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Smart phone penetration and technological innovations are supporting the growth of mobile payments.

Smart phone penetration should reach 75% of the world population by 2020



New technologies such as Biometrics, NFC* & POS** will boost security and usage



New regulations are supporting the shift to mobile payments

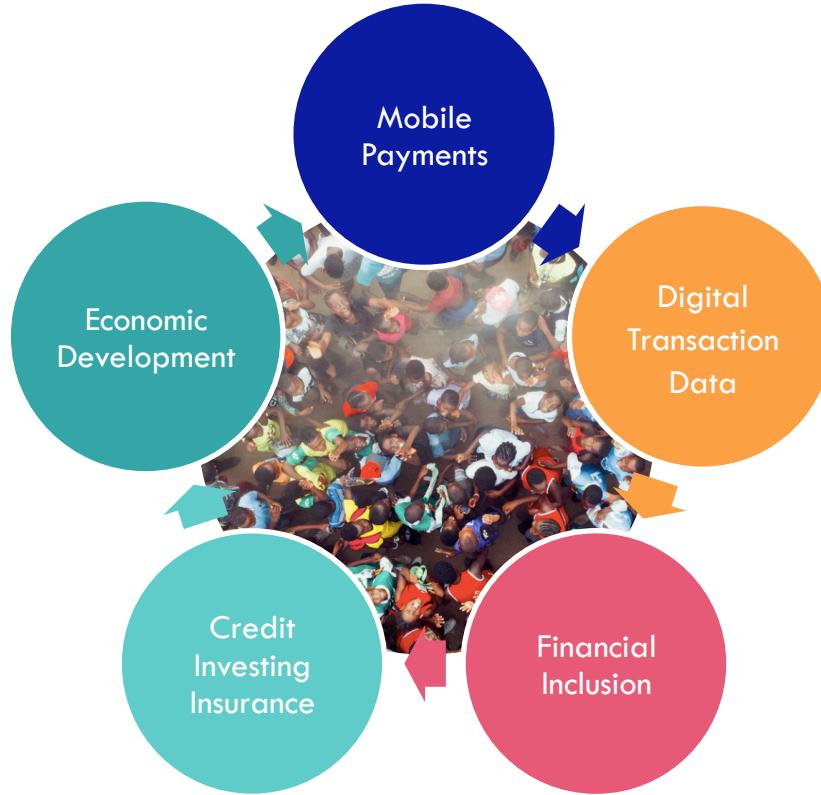
- Demonetization in India and the introduction of a unified digital payments interface.
- China Regulatory Authority encouraging development of digital payment platforms.



5. MOBILE PAYMENTS

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**Mobile payments are key
to financial inclusion
in developed and
emerging markets.**



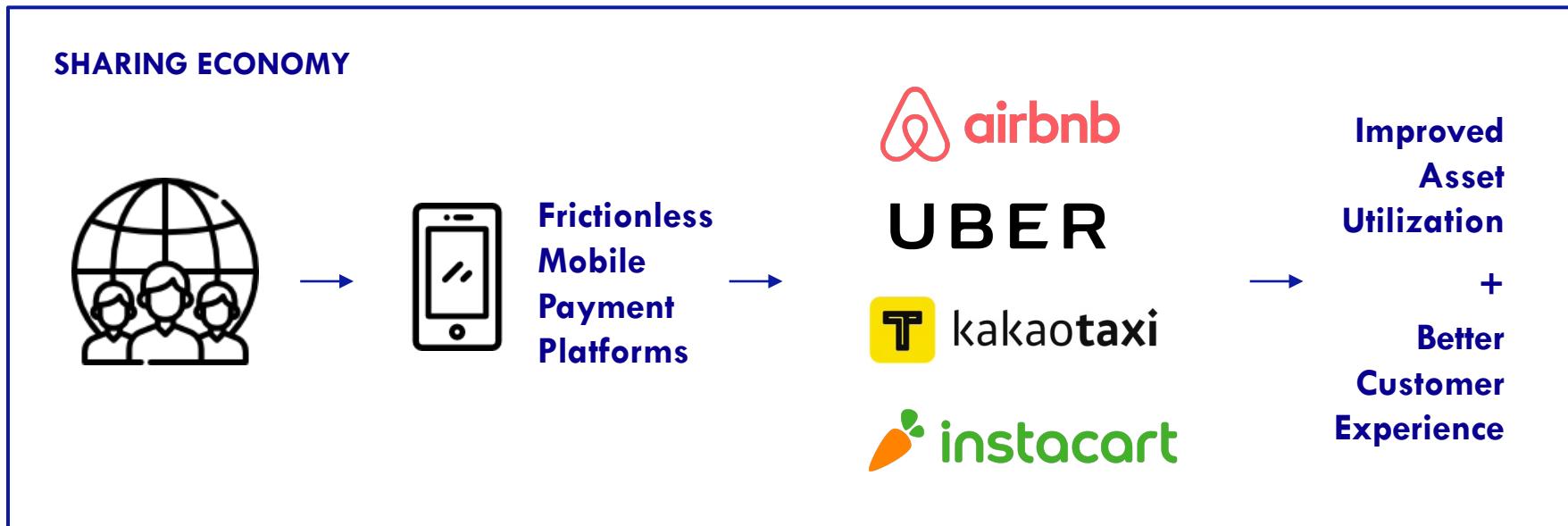
Source: ARK Investment Management LLC



5. MOBILE PAYMENTS

ARK INVEST | BIG IDEAS 2017

Mobile payments will enable frictionless payments in the sharing economy.





5. MOBILE PAYMENTS

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SIZING THE OPPORTUNITY

Mobile Payments Are Reaching An Inflection Point

The transaction value that flows through mobile should grow by more than 5X from 2015 to 2020.





5. MOBILE PAYMENTS

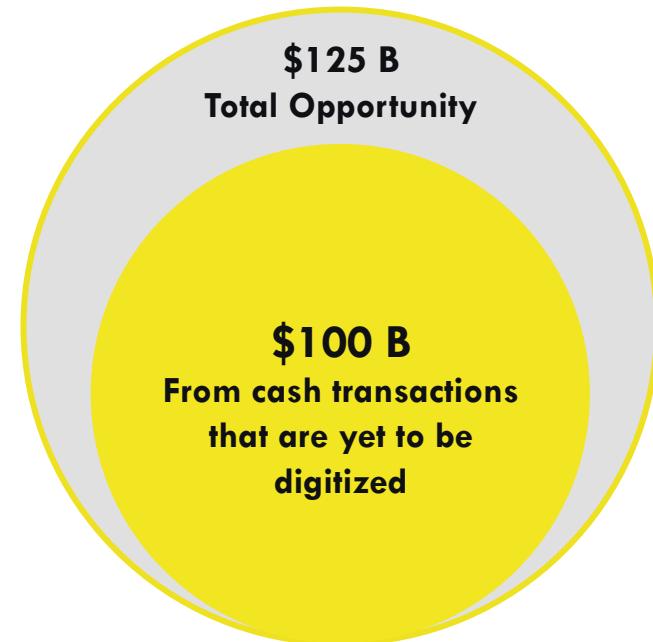
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SIZING THE OPPORTUNITY

Mobile Transaction Data Is A Hidden Asset

ARK estimates a \$125 billion opportunity from transaction data:

- 20% of global transactions are already digital, providing a roughly \$25 billion monetization opportunity.
- The remaining 80% of cash transactions are moving increasingly into mobile, adding \$100 billion to the transaction data opportunity.



Source: ARK Investment Management LLC



5. MOBILE PAYMENTS

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Additional Research:



RESEARCH BLOGS

Data from Cash Disruption: A Clear Advantage for Fintech Firms



Fintech Explained—The Financial Revolution Has Just Begun



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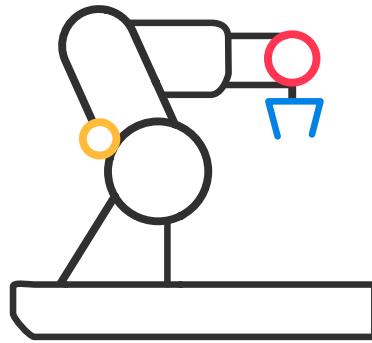
Julia Hemmendinger, Analyst

jhemmendinger@ark-invest.com

 [@juliahARK](https://twitter.com/juliahARK)

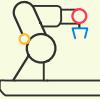
6. ROBOTICS

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“Closely coupled machine-human manufacturing capabilities will drive accelerating productivity throughout the physical economy.”

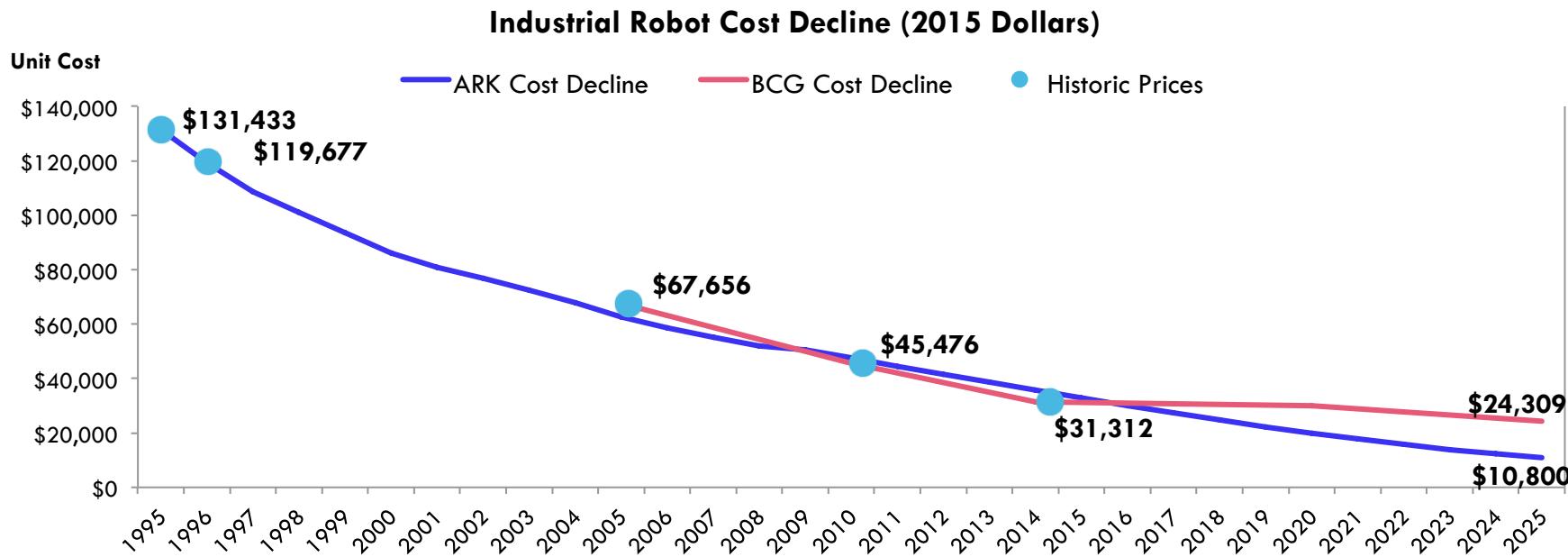
– Brett Winton (2017)



6. ROBOTICS

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**Industrial robots are continuing to decline in cost
and are thereby expanding the addressable market.**

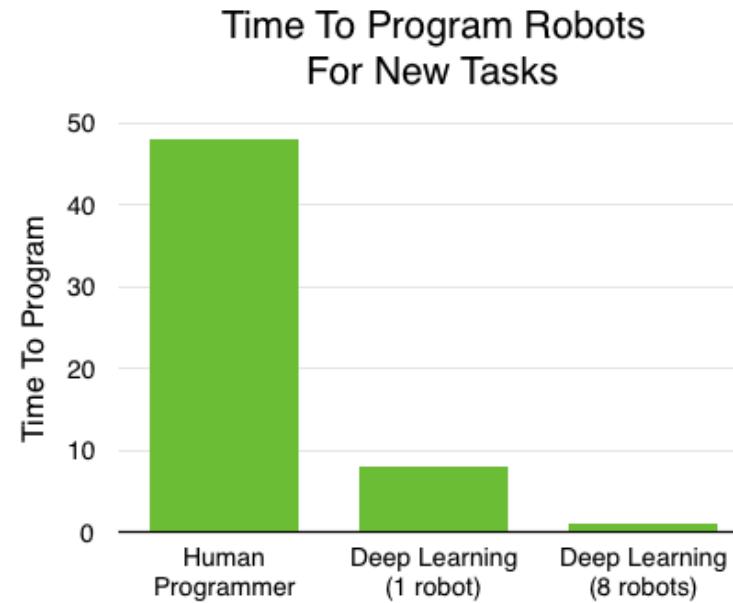
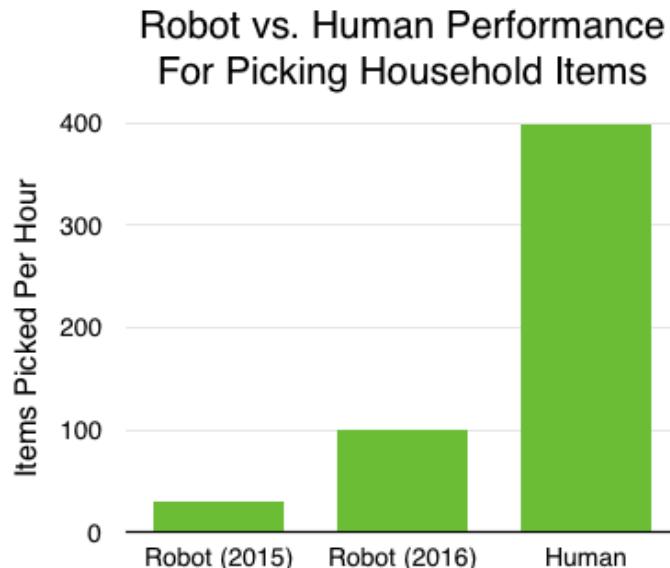




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Collaborative robots and deep learning are shrinking programming costs and increasing use cases for robotics.



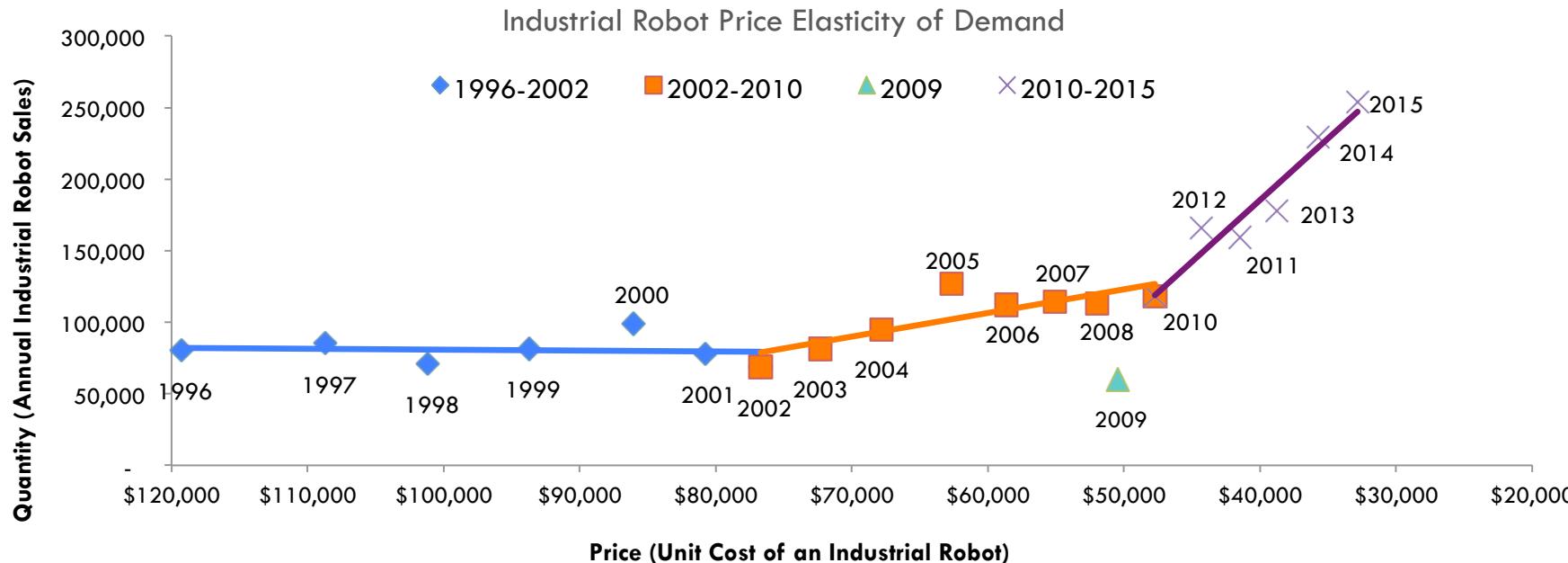
Source: Amazon | Preferred Networks



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Industrial robots have crossed the tipping point where cost declines grow the market.



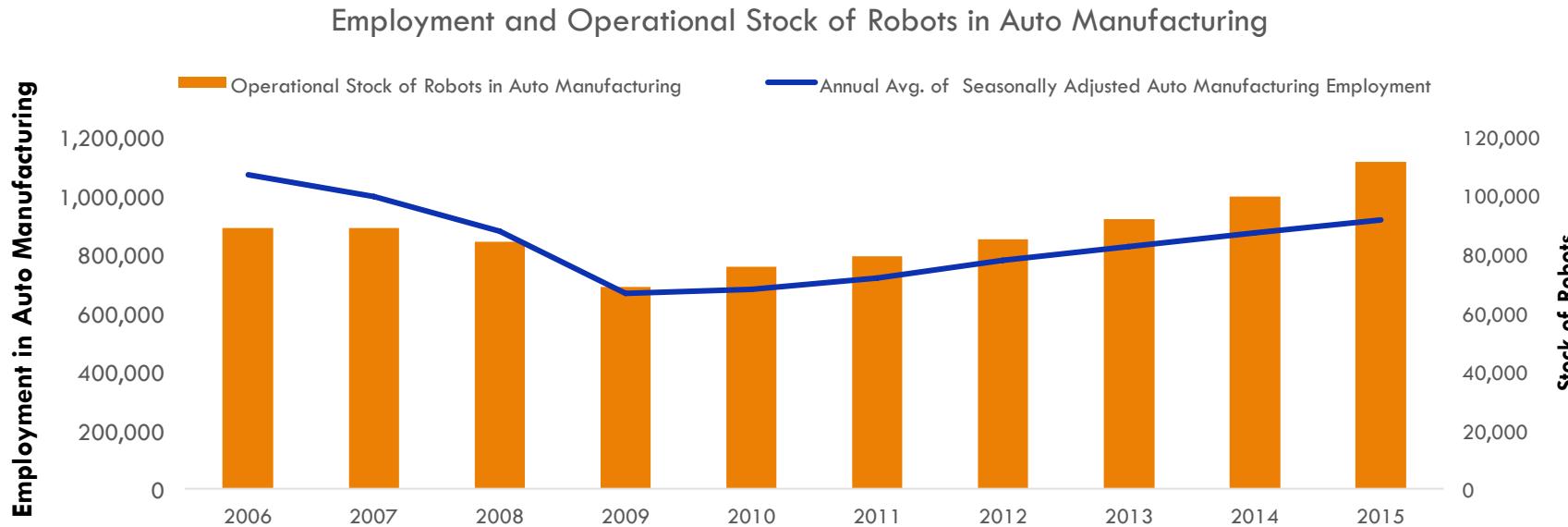
Source: ARK Investment Management LLC, UNECE, International Federation of Robotics



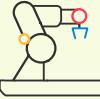
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Employment in the auto industry has continued to grow even as the number of robots has increased.



Sources: Bureau of Labor Statistics, International Federation of Robotics



6. ROBOTICS

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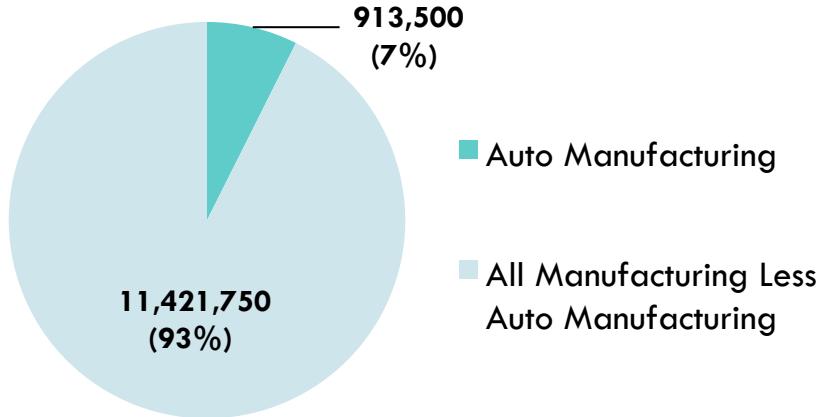


SIZING THE OPPORTUNITY

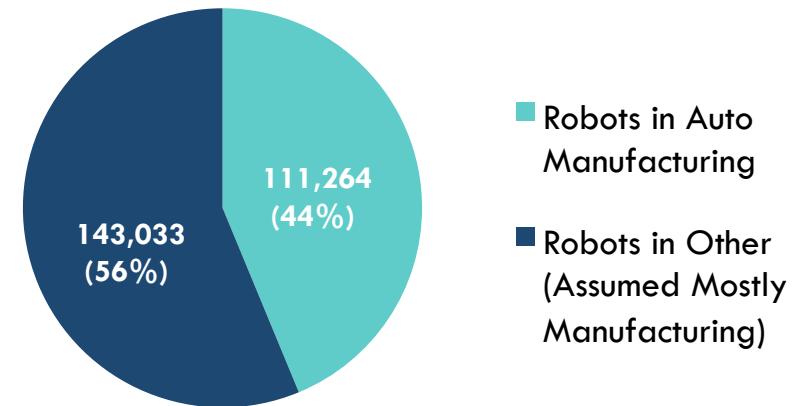
ARK anticipates increased adoption of automation in many industries.

Industrial robot sales have been driven by the auto industry, but as upfront capital costs and programming costs decline, all manufacturing firms should be increasing adoption.

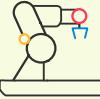
2015 Manufacturing Employment Breakdown



2015 Stock of Industrial Robot Distribution



Sources: Bureau of Labor Statistics, International Federation of Robotics



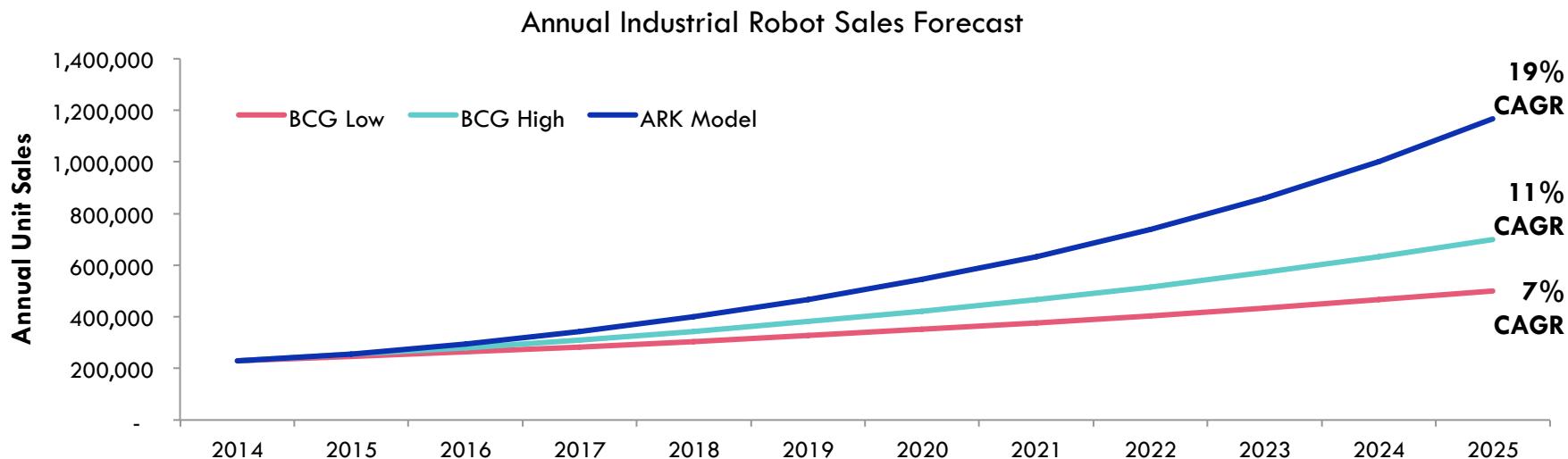
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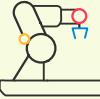


SIZING THE OPPORTUNITY

Robot sales growth should accelerate, thanks to decreasing capital costs, lower programming costs, and many more use cases.



Sources: ARK Investment Management LLC, Boston Consulting Group, International Federation of Robotics



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Additional Research:



WHITE PAPER

The Future of Automation

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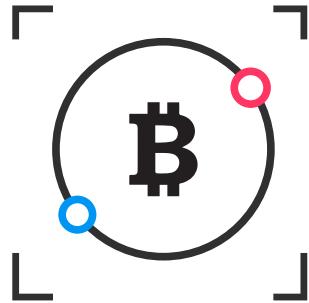


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7. CRYPTOASSETS

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“Blockchain could slash the cost of transactions
and reshape the economy.”

– *Harvard Business Review (2017)*



7. CRYPTOASSETS

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Cryptoassets

We believe that bitcoin and other cryptocurrencies are not just “currencies”. Traditional asset classes differ in three ways: politico-economic features, correlation of price movements, and risk-reward profiles. “Cryptoassets” can be considered a new asset class entirely.¹ Verticals within cryptoassets include:

○ Cryptocurrencies

Uses: means of exchange, store of value, unit of account
Examples: bitcoin, litecoin, monero, zcash

○ Cryptocommodities

Uses: cloud storage, compute cycles, bandwidth
Examples: ether, golem, storj, sia

○ Cryptotokens

Uses: consumer facing distributed applications
Examples: augur, gnosis, swarm city, steemit

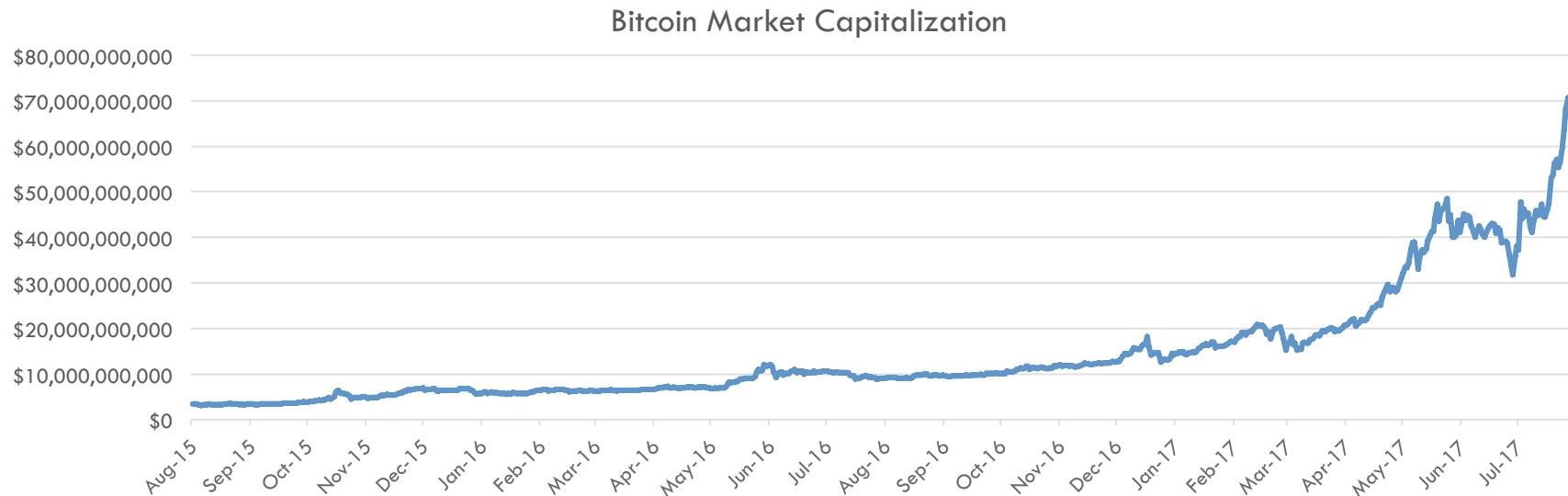


7. CRYPTOASSETS

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Bitcoin: From a \$3B to a ~\$72B Market Capitalization in Two Years

Shown below is the total USD value of bitcoin supply in circulation, as calculated by the daily average market price across major exchanges.



Source: blockchain.info, as of 8/18/2017



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At ~\$72B, Other Cryptoassets Combined Now Rival Bitcoin's Market Capitalization

Total Market Capitalization (Excluding Bitcoin)



Source: <https://coinmarketcap.com/charts/>, as of 8/18/2017



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The ‘Crypto World’ includes 850 Assets, and Counting

Top 20 Cryptoassets in August 2017

1	Bitcoin	6	Litecoin	11	BitConnect	16	BitShares
2	Ethereum	7	NEM	12	Monero	17	Steem
3	Bitcoin Cash	8	NEO	13	Stratis	18	Lisk
4	Ripple	9	Dash	14	Waves	19	Bytecoin
5	IOTA	10	Ethereum Classic	15	Zcash	20	Siacoin

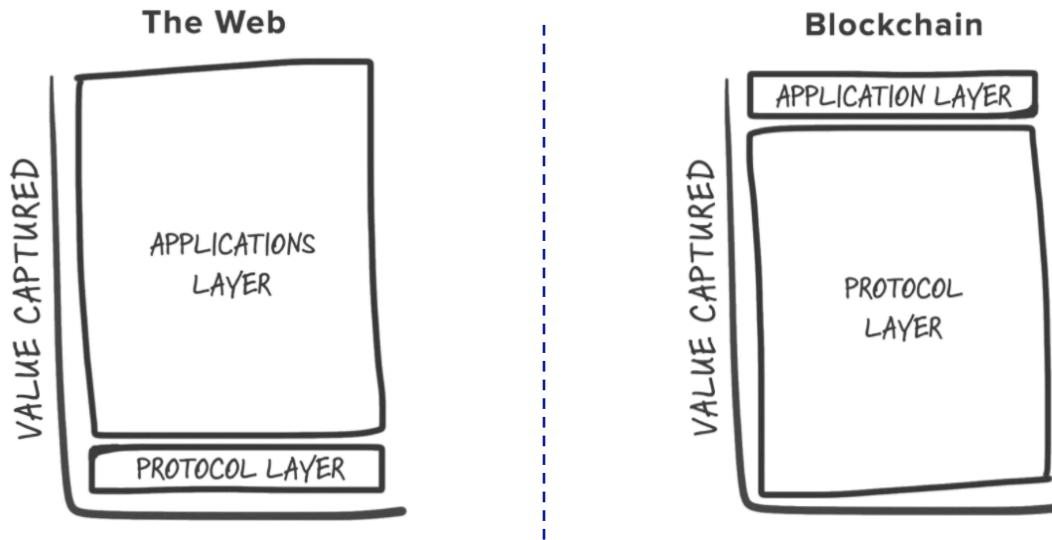


7. CRYPTOASSETS

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How does blockchain technology compare to the web?

Unlike the web, blockchain based systems incorporate native units, like bitcoin, within a protocol. In order for the protocol to function, those units must have value. As more applications are built on top of the protocol, the value of the native unit appreciates, and the value accrues to the protocol layer more than the application layer.



Source: <http://www.usv.com/blog/fat-protocols>



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SIZING THE OPPORTUNITY

Blockchain Technology Is Going To Revolutionize The Transfer Of Digital Assets

Blockchain technology will make the transfer of assets to anyone, anywhere, as seamless as sending an email.

- By 2020, bitcoin transactions likely will reach **\$2 billion daily**, a **100%** increase from today.
- Remittances - **\$600 billion** in transaction volume – will benefit from a **90% drop in costs** thanks to bitcoin.
- Blockchain enables real time trade settlement, **freeing up hundreds of billions of frozen dollars**.



7. CRYPTOASSETS

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Additional Research:



WHITE PAPER:

Bitcoin: Ringing The Bell For A New Asset Class

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Blockchain Products Lead*

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