Theorality 2016
How transformational ideas are becoming business reality

September 2016
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For important disclosures please refer to the last pages.
Foreword

Like much of your investment portfolio, the broking industry is facing fundamental shifts which pose existential questions for traditional business models. Against that backdrop, this analyst sat down with CLSA’s management in June. The goal? To discuss his latest incarnation at the blue and yellow, Global Head of Thematic Research. What does that mean?

With a brief to ensure we drive discourse on the ‘core investment themes which matter’ the first task was quickly self-evident: figure out what the hell those themes are. To attack that challenge we decided to take a step back and try to put newsflow in context. We needed a conceptual framework, a lens with which to interpret and prioritise. That is exactly the gap this product seeks to close.

To this end we identify five industry-specific themes which have secular and global significance, but which also reach beyond their core sectors:

- **Internet X.0**: hyper-scale dominators will push a contextual, conversational, video-centric internet.
- **Advanced services**: the lines between online and offline are increasingly irrelevant. Tomorrow’s winners understand this.
- **Fintech**: much of the “innovation” has been observable for decades, but blockchain is new and will change the world.
- **Advanced manufacturing**: companies which connect their machines, teach them with AI and train their people in VR will win.
- **Advanced transportation**: the future of transport is already here; it’s about the ability to adjust to the new reality.

The inaugural Theorality report attempts to makes sense of the noise. The conclusions? There are three enabling technologies which underpin multiple innovations and significantly impact virtually every industry globally. Investors must take the time to understand and track them:

- **Artificial intelligence**: how machine learning is reshaping not just digital but physical industries as we know them.
- **Connected everything**: the Internet of Things is too esoteric and functionally a decade away. To better understand it, focus on where machines are going online to drive the bottom line.
- **Rendered realities**: memories of the 3D fad still haunt this analyst, but virtual reality may give paraplegics movement.

While these themes are critical, and we are confident investors will feel vindicated if they commit the time to understand them, they do not easily scratch that perennial itch: an idea which primarily drives the revenues or costs of a specific stock or industry. After all, ultimately the goal is to get back to companies and share prices.

As our first attempt at such a report, we would not pretend it is exhaustive. There are a number of trends we did not have time to tackle. Energy specialists might wonder, where’s the advanced energy chapter? CLSA has done excellent work here, much of it led by Rajesh Panjwani. The consistent thread is aptly summarised in the new CLSAU report *Gradual greening* by Vaclav Smil. Energy transitions are multi-decade prospects. Rajesh assures us we have time to revisit this theme.

Other themes which interest us include nanotechnology, demographics, governance and macro-overlays. Nanotechnology, for now, seems years from commercialisation. Demographics are critical and interesting; watch this space. For governance we release our 2016 CG watch this week. On macro we will collaborate with the economics team shortly. There is more to come from CLSA’s renewed thematic drive.

For now we hope you have as much fun reading this report as we did writing it. We believe it is worthy of your time. While we know it does not have all the answers, it will help you ask the right questions. In this analyst’s experience, that is more than half the battle. Happy hunting.
Artificial intelligence
Finding its voice
Artificial intelligence advances and data availability will massively scale the productivity of humans, machines and institutions

- Movies often depict artificial intelligence (AI) as a futuristic utopia/dystopia realised decades from now. In reality increasingly complex applications are already pervasive today.
- Solving complex games has been a key means for developers to test emerging AI capabilities and to educate the public. The evolution of computer games has also played a crucial role.
- Typically, the more general the attempt to apply AI, the more disappointing the result. Just, “Ask Siri” circa 2011. But targeted applications are gaining traction. Amazon’s Echo launched very narrowly but is quickly broadening into a digital home platform.
- AI has made real-time translation, the long-held global dream, a reality. Elsewhere a new army of bots will solve for complexity via specialisation, though not always successfully.
- Ultimately companies are targeting less context-specific general artificial intelligence, but will need outside knowledge and often fail in order to succeed, like Microsoft and Apple.
- Asia is beginning to meaningfully invest in AI, while many in the US worry about the dominance of a few large companies; especially Google, which partially inspired Open AI.
- AI is arguably the most transformational technology of our time; it introduces moral questions (like can machines decide to kill?) and even existential ones (will the machines kill us all?).
- Companies are aiming for moonshot ideas like curing cancer and predicting potential disaster-level events; we do not know where AI will take us, we just know it is profoundly important.
AI is often depicted as a far off futuristic utopia/dystopia whereas its increasingly complex application are already pervasive today

Perception . . .
AI cultural icons

1968 - A 2001 Space Odyssey...
...intelligent space ship versus humans; who is at fault...

1977 – Star Wars...
...the machines are obedient and take care of us...

1984 – Terminator...
...the machines will kills us all, but for one time travelling ally...

1999 – The Matrix...
...we are all slaves to the machine we just don’t know it...

1999 – Terminator...
...the robots take control, but for that one good guy again...

2004 – I, Robot...
...we fall in love with our AI (or is it just because it’s Scarlett)

2013 – Her...

Source: CLSA, Google, Spotify, Amazon, Skype, Google reCAPTCHA

. . . versus reality
The most common applications of AI today

Search is being advanced by AI
Powered by

As are purchase recommendations of numerous kinds
Powered by

Personal Assistants like Siri and Echo are powered by multiple AI platforms
Powered by

Increasingly useful translation engines are popular AI engines
And

And we have sent AI’s to detect AI’s

... Oh no... Have the machine wars already begun?
Solving complex games has been a key means by which developers have tested emerging AI capabilities and educated the public at large.

**The evolution of AI gameplay**
Iconic man versus machine battles, 1967-2016

- **1967**
  - Chess match
  - Mac Hack beat Hubert Dreyfus (MIT AI)

- **1996**
  - Chess match
  - Deep Junior beat Garry Kasparov (IBM AI)

- **2003**
  - Chess match
  - Deep Blue lost to Garry Kasparov (IBM AI)

- **2011**
  - Shogi match
  - Ponanza beat Shinichi Sato (Issei Yamamoto, professional player)

- **2013**
  - Go match
  - AlphaGo beat Lee Sedol (Go champion)

- **2015**
  - Jeopardy quiz show
  - Watson beat Rutter and Jennings (IBM AI, quiz champions)

- **2016.3**
  - Poker match
  - Claudico lost to professional players (CMU AI)

Source: CLSA, Wikispace, Wiki Commons, kasparovagent.com, Watson 2016, Riverscasino, Google
The evolution of computer games has also played a crucial role in developing the human and intellectual capital within the field.

### AI in the gaming industry

#### Evolution of AI techniques

**Arcade era**
- Highly simplistic AI
- Limited movement within a set number of patterns
- Static script and rule-based approach
- Little or no interaction with the movements of the player
- The beginning of AI development technique in games

**PC/console era**
- Introduction of more adaptive computer strategies, more dynamic and complex behaviors
- Enhanced system autonomy
- Interacts with multiple computer/non-computer characters and objects

**Internet era**
- Complex near real-world models are applied
- Open-ended; large amounts of freedom and no specific goals
- A tool for AI development

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**Source:** CLSA, Wikipedia, Tech Insider, EA Maxis, Starcraft, Reddit, Minecraft

- Pong (1972)
- Space Invaders (1978)
- Super Mario (1985)
- Street Fighter (1987)
- FIFA Soccer (1993)
- Minecraft (2011)
- StarCraft (1998)
- The Sims (2000)
- Black & White (2001)

Acquired by Microsoft in 2014, Minecraft is being used as a platform to develop better AI with project Malmo released as an open source tool-set in July 2016.

Demis Hassabis, the founder of DeepMind (and of Alpha Go fame, acquired by Google in 2014) first cut his teeth in the field of AI by working on game development (Black & White).
Typically, the more general an attempt to apply AI the more disappointing the result; just “Ask Siri” circa 2011

Apple’s big AI bet: Siri
Siri launched in October 2011 with the iPhone 4S

Siri was launch with great fanfare on a platform of “ask it anything” but the underlying reality of doing little well

“Siri is an intelligent assistant that helps you get things done just by asking”
(Apple’s Advertisement)

But massively underwhelms
So why was Siri such a failure initially

- **Rushed to release**
  After being acquired by Apple in 2010, a beta version of Siri was rapidly released as a feature of the iPhone 4S in 2011 when it was not fully ready to be deployed, i.e. no support for multiple languages

- **Launched as general purpose assistant**
  Instead of focusing on a specific task, Siri was ambitiously designed to serve as a general purpose assistance but it lacked a sufficient skill typology to guide requests or enable answers

- **Poor voice recognition**
  Siri’s voice recognition rate was poor upon launch with poor accuracy and response speeds

- **Limited AI capability**
  The lack of specific skills meant Siri’s ability to interpret and execute commands was limited, often failing to provide smart or contextual answers

- **Closed platform**
  Siri was developed in a closed platform, limiting the access of third-party developers, which hindered its capacity to expand into other services

- **No memory**
  Siri was unable to remember past conversations or the behaviour patterns of users and failed to customize to individual user needs

Source: CLSA, Apple, PC Magazine, Business Insider, CNET
However the more targeted applications are gaining real world traction and in many cases seamless acceptance

**Machine vision**
Facial recognition has yielded scalable successful applications

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<th><strong>SNS</strong></th>
<th><strong>Police vehicle</strong></th>
<th><strong>Payment</strong></th>
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- **Airport**: Verifying passenger’s identities using the data stored in biometric passports has become common at airports, and is accepted, and even loved, by travelers.
- **SNS**: Identifies human faces in digital images
  - Automatically tags users in photos
- **Police vehicle**: Mounted with a 360-degree rooftop camera array
  - Automatically scans for criminal faces within a 60-meter radius
- **Payment**: Allows users to buy items without pulling out a wallet
  - When the customer says “I will pay with Google”, the camera identifies him/her using facial recognition

Source: CLSA, Heathrow Airport, Facebook, WSJ, Google
Amazon Echo started with a very targeted application of voice recognition and is quickly broadening into a digital home platform.

Amazon’s sleeper AI hit: Echo
Echo launched in November 2014, powered by Alexa

Echo was launched in such a tight beta during 2014 that “CNet had to turn to eBay just to get one to review” concluding “a beta product if there ever was one”

Until February 2016:
“I didn’t know I wanted to talk to my house until I talked to my house. Now, after living with the Amazon Echo for a year, I talk to it every day.”

Source: CLSA, Amazon, Tech Insider, USA Today, CNET

Under promise, over deliver
A tight beta and no promises enabled growth

- **Limited release**
  Before its launch, Echo had been under development for at least four years and initially launched to Amazon prime customers by invitation only.

- **Launched as specific purpose assistant**
  At its initial launch, Echo was perceived as a “smart home audio speaker” which could carry out a few simple and specific tasks such as answering queries and creating to-do lists.

- **Excellent voice recognition**
  Echo has excellent voice recognition as Amazon developed its voice recognition technology while working on the development of the Kindle by acquiring key startups in the field.

- **Less demand on AI capabilities**
  As Echo sought to deliver specific skills which were added over time, a complicated and integrative AI was not required and its available skills lead expectations, not the other way around.

- **Open platform**
  Amazon designed Alexa as an open platform offering the “Alexa Skills Kit (ASK)” which invited third-party developers to connect company devices or services with Echo, thereby expanding the realm of Echo’s “skills” (2,780+ skills as of September 2016).

- **Learns**
  Alexa, Echo’s brain, runs in the cloud and gets smarter via experience by adapting to user speech patterns, vocabulary, and personal preferences.

"Amazon Echo Really is Revolutionary”
Tech Insider

"The next big platform for the near future”
Steve Worzniak

"Echo could hear my voice even when music was playing loudly”
USA Today
Alexa has been a secret sauce and is now easily deployable via APIs with its partner's growing from 135 in January to 1,400+ today

How Echo works
Hardware and the underlying AI, Alexa

- **Echo**
  - Bluetooth speakers
  - 360° omni-directional audio with enhanced sound system

- **Alexa**
  - Underlying AI
  - An open platform which provides integrated voice recognition and skill development for third parties

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Alexa voice service (AVS)
“Brings voice capabilities to your connected device”

- AVS is a scalable cloud service that adds voice-powered experiences to any connected device – as long as it has a microphone and a speaker.
- It integrates Alexa services into smart watches, home appliances or whatever developers can conceive.

Alexa skill kit (ASK)
“A free SDK that lets you easily build voice experiences”

- Helps create an ecosystem of all connected goods and services which can conveniently and simply be activated by Alexa.
- Through this integration, the Echo AI system becomes ubiquitous and more manageable everywhere.
- Alexa only works for skills you “enabled” using specific commands. This means your expectations of Alexa automatically match to what she can do.

Alexa Fund
“$100 million in investment to fuel voice technology innovation”

- A venture capital fund set up to invest in companies that can deliver new value through Alexa
- Launched with seven initial investments

Source: CLSA, Amazon, Tech Crunch
While Echo solves problems users barely knew they had, the long-held dream of real time translation is finally becoming a reality.

**Skype Translator**
*Skype, 2015*

- Provides real-time translation for both audio and text
- Built on machine learning technology, its performance improves the more it is used
- Available in six voice languages – English, French, German, Italian, Mandarin, Spanish and 50 messaging languages

"*Skype Translator is the most futuristic thing I’ve ever used*"

Peter Bright, Tech Editor at Ars Technica

**Pilot**
*Waverly Labs, to be launched in 2017*

- A smart wearable Bluetooth earpiece connected to smartphones providing real time translation of spoken language
- Still in “late alpha” development and scheduled for launch in Spring 2017
- Available in English, Spanish, French, Portuguese and Italian

"*The gadget straight out of science fiction has come to life*"

Marshable

Source: CLSA, Skype, Waverly Labs, Arc Technica, Marshable
And a new army of bots will solve complexity through specialisation for better interactions like DoNotPay and Amy Ingram

**DoNotPay**
Free robot lawyer fighting parking tickets

- Rule-based approach to specific problems
- Developed by 19-year-old Joshua Browder
- With a success rate of c.64%, DoNotPay has overturned 160,000 parking tickets in London and New York in nine months

**Amy Ingram**
X.ai’s artificial intelligence personal assistant

- Conversational AI with adaptive logic to attempt human level efficiency
- An intelligent assistant which helps scheduling via email with your colleagues like she’s human
- Beta version is free (extremely long waiting list); plans to charge US$9-15 per month for full service upon final release

Source: CLSA, DoNotPay, X.ai, CNN
Because complexity is very hard to solve for flexible solutions can yield unpredictable results as Microsoft painfully discovered with Tay

**Tay.ai: teen-girl-like chatbot**  
Microsoft’s launch of artificial intelligence chatbot

**But accidently turned into . . .**  
Showing how machine learning can go wrong

- In March 2016, Microsoft launched its AI chatbot Tay on Twitter
- Tay was designed to interact with and learn from the users, targeting millennials
- The aim was to “experiment with and conduct research on conversational understanding”

- However, within 24 hours from the launch, Tay started to make inappropriate tweets including racist, sexist and drug-related tweets
- Microsoft apologised and took Tay offline for upgrades

Source: CLSA, Tay.ai Twitter
But importantly Microsoft has shown the requisite willingness to learn from mistakes and uncharacteristically integrate outside knowledge.

**Microsoft’s AI vision**

Microsoft’s view of the five key assets for success in AI:

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<th>Description</th>
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<tr>
<td><strong>Conversational canvas</strong></td>
<td>A place where communication takes place</td>
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<td></td>
<td>Where people talk, text or message a lot</td>
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<tr>
<td><strong>AI brain</strong></td>
<td>A sophisticated mental model of the world</td>
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<td></td>
<td>Microsoft has been making efforts on this for nearly 20 years</td>
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<tr>
<td><strong>Access to social graph</strong></td>
<td>People’s online activity involving their family, friends and coworkers</td>
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<td></td>
<td>Microsoft will acquire LinkedIn and its 433 million users by end-2016</td>
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<tr>
<td><strong>Operating platform</strong></td>
<td>A platform where AI programs operate</td>
</tr>
<tr>
<td><strong>Network of developers</strong></td>
<td>Developers who are willing to build on your platform and pay for the privilege</td>
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Source: CLSA, The Verge
WWDC 2016 represented a meaningful pivot to AI for Apple via a cross-platform Siri as it chases the Alexa example

Apple’s key changes to Siri
Key takeaways from WWDC 2016

Cross-platform/device integration
Siri will be ubiquitous
- Apple will bring Siri to Mac’s OS Sierra
- With Siri available on the iPhone, other mobile devices and desktops, it becomes more accessible and provides seamless inter-device experiences

(More) Open platform
Opening up Siri to third-party apps
- Apple opened up a software development kit (SDK) for Siri (with tight controls, hey it’s Apple) enabling developers to integrate apps with Siri
- This will reduce app fatigue by letting people do more things with voice control on their iPhones

Embedding more powerful AI
Siri will draw on more AI capabilities
- Siri will be empowered with stronger computing capabilities and software algorithms
- Siri will become smarter by being able to scan through people’s communications, make suggestions and anticipate what people want to do

Source: CLSA, The Washinton Post, WSJ, Indian Express
Asia is beginning to meaningfully invest in AI with industry powerhouses in China and Japan seeking to drive the revolution

Asia pushing for AI development
Leading Asian companies developing AI

**Baidu 百度**

“Artificial intelligence will continue to be an unceasing core for Baidu innovations.”

Robin Li, CEO

- Established Baidu Research centres to work on fundamental AI research
- Leads voice recognition technology with its “Deep Speech” which can transcribe better than humans
- Currently developing self-driving cars

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**Alibaba Group 阿里巴巴集团**

“The future of Alibaba will involve artificial intelligence and robots...

...Alibaba thinks (of) itself as a data company, not an ecommerce company.”

Jack Ma, CEO

- Alibaba’s AI successfully predicted the winners of Chinese reality show “I Am Singer”
- Deployed AI to assist with customer service and traffic pattern predictions for its flagship ecommerce business

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**Tencent 腾讯**

“We will transform ourselves, from doing everything on our own to operating only the core platforms, digital content and financial businesses.”

Ma Huateng, CEO

- WeChat, China’s largest mobile chat network run by Tencent, uses data intelligence and deep learning to improve its marketing
- Lead a US$10 million series funding to invest in AI technology startups

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**SoftBank**

“The Singularity is coming. Artificial intelligence will overtake human beings not just in terms of knowledge, but in terms of intelligence.”

Masayoshi Son, CEO

- Acquired ARM this month to play a key role in bringing about advanced AI
- Collaborates with Honda in the development of AI assistance for drivers

Source: CLSA, Wiki Commons, Wikipedia, Tencent Press Release, WSJ, Bloomberg, South China Morning Post, BBC
While many industry players worry about the dominance of a small group of very large network businesses, especially Google

How long did it take Google to dominate?
Where Google does and does not dominate and how long it took

Evidence of Google’s AI dominance
Based on the network effect

- Google open-sourced TensorFlow and the platform for simplifying AI programming which competitors are reluctant to use. By July 2016 the number of bookmarks on Github for programmers breached 80% of the Linux level (started in 1991).

- Google acquired DeepMind for approximately half a billion dollars in 2014 with no revenue disclosure and no specific monetisation plans.

- Google’s 3.5bn daily searches represent a 66% share of global search and is a massive information advantage for training its search AI Rank Brain.

- Google maps is used by billions of people around the world, collecting unequalled data on location, route and search history which can again enable far greater ‘learning’.

- Google is one of the most aggressive acquirers in AI having made nine AI company acquisitions since 2011, outnumbering its competitors.

Source: CLSA, Google, Bloomberg, NetMarketShare, Singularity University, CB Insights
AI is arguably the most transformational technology of our time introducing the truly existential question: will it be our ultimate end?

The AI risks are real
Many of the world’s greatest minds fear AI

"Artificial intelligence is humanity’s biggest existential threat"
Elon Musk

"Success in creating AI would be the biggest event in human history. . .
. . . Unfortunately, it might also be the last, unless we learn how to avoid the risks."
Stephen Hawking

"I am in the camp that is concerned about super intelligence. . .
. . . I don't understand why some people are not concerned."
Bill Gates

Open AI is one response
Open AI’s mission is to ensure AI is a force for good

Launch of OpenAI
Elon Musk’s US$1bn initiative to free AI
- Founded in December 2015 as a non-profit AI research company
- Sponsored by Elon Musk, Sam Altman, Peter Thiel, Greg Brockman and other venture capital leaders

Goal
Efforts to democratize AI research
- OpenAI’s goal is to advance digital intelligence in away most likely to benefit humanity as a whole
- Seeks to liberalize AI research from domination by large institutions (ex. Google and Facebook) and prevent its potential dangers (but funded by specific groups)

Strategy
Open collaboration among researchers
- 'Freely collaborates' with other institutions and researchers by making (most of) its patents and research open to the public

Source: CLSA, OpenAI, Observer Opinion
Only slightly less profound are the questions around the emerging capabilities of machines to kill without human intervention

**ALPHA**
Psibernetix, University of Cincinnati

![Alpha](image)

- Alpha, an artificially intelligent fighter pilot system which has defeated tactical experts in air-to-air combat simulation
- Using “Genetic Fuzzy Tree” (GFT) systems, a subtype of fuzzy logic algorithms, which show a human-like approach to problems
- Available for training and running on small and affordable consumer-level computers

“the most aggressive, responsive, dynamic and credible AI I’ve seen to date.”

- Gene Lee, Retired U.S. Air Force Colonel

**Drone Fighter Bomber**
Kratos Defense

![Drone Fighter Bomber](image)

- The U.S. Air Force awarded US$40m to Kratos Defense for the development of a drone fighter bomber, or the Low-Cost Attritable Strike Unmanned Aerial System Demonstration (LCASD)
- LCASD is relatively affordable at US$2-3m per drone and is expected to revolutionize drone air warfare

**Unicum**
United Instrument Manufacturing Corporation (OPK), Russia

![Unicum](image)

- OPK developed Unicum, an AI software enabling military robots to undertake decisions and perform tasks autonomously
- Unicum can be installed on the ground, in the air or at sea and also has the ability to act independently or in groups

"With Unicum, the robots will be capable of executing tasks independently, to see and evaluate the situation, plotting new courses as well as communicating with other machines."

- Sergey Skokov, OPK Deputy Director

Source: CLSA, University of Cincinnati, Kratos, Rostec, UC Magazine, Popular Mechanics, Daily Mail
Companies are aiming for the moon with ideas like curing cancer and predicting potential disaster level events in advance

**Banjo**  
Founded in 2011

- The world’s first disaster prediction engine
- Its “Crystal Ball” organizes social and digital signals by location and track events in real-time
- Recognizes underlying patterns to predict a near-future event; its predictive ability improves as its models learn

**Enlitic**  
Founded in 2014

- Founded by Jeremy Howard, a data scientist and a former Chief Scientist at Kaggle
- Produces deep-learning software which can analyze x-rays to make medical diagnostics and decisions for clinical treatments
- The company argues its system is 50-70% more accurate and is 50,000 times faster than humans

**Grail**  
Founded 2016; mission: cure cancer

- Jeff Huber, CEO, a former senior Google executive who lost his wife to colon cancer
- Spin-off from Illumina, the world’s largest DNA-sequencing company
- Enables early detection of many types of cancer through a blood test called “liquid biopsies” which could cost US$1,000 or less

“We hope today is a turning point in the war on cancer.”

- Jay Flatley, Illumina CEO

Source: CLSA, Enlitic, Grail, Banjo
Just as we did not know the iPhone would lead to Uber we can not know where AI will take us, we just know it is profoundly important.

**Kaggle: Home for Data Science**

*Founded in 2010*

- An open crowdsourcing platform for competing, learning and sharing within machine learning
- Provides tools and datasets for machine learning to developers
- The largest data community in the world with over 536,000 registered users (as of May 2016)

**UNU: Swarm Intelligence**

*Developed by Unanimous A.I., in 2014*

- An AI platform using the collective knowledge of a group of people to form its own opinions, preferences and predictions
- Uses "swarm intelligence", which follows the natural workings of bee communities which find solutions in swarms
- Predicted 11 of 15 Oscar winners correctly in 2015, and now hosts the first-ever AI-backed "Ask Me Anything" forum on Reddit (eg. "Who will win the US election 2016?")

**DeepMind: Saving Electricity**

*Has DeepMind already paid for itself?*

- According to Bloomberg, DeepMind AI improved power usage efficiency 15%, saving Google millions
- The internet giant used 4,402,836 MWh in 2014, of which a significant proportion was for its data centers
- Google acquired DeepMind for US$500m in 2014, an AI company well known as the developer of AlphaGo

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Source: CLSA, Kaggle, Unanimous A.I., Google, Bloomberg, Engadget
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