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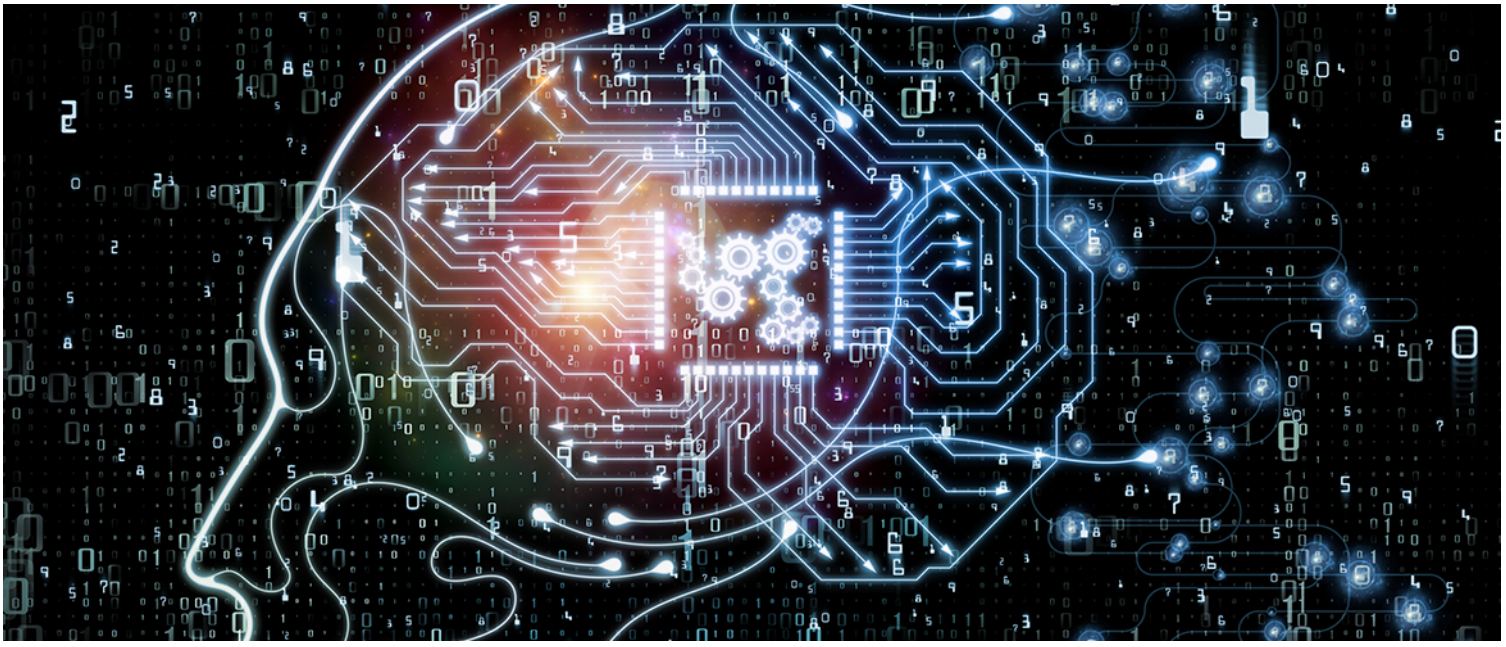


Artificial intelligence – a promising investment opportunity on a global scale

JANUARY 2019

Content

Introduction

> *"As technologist, I see how AI and the fourth industrial revolution will impact every aspect of people's lives"*
>
> Fei Fei Li

"Can a machine think?" asked Alan Turning in 1950 (in his seminal paper called "Computing Machinery and Intelligence"). This is the first occurrence of Artificial Intelligence (AI) long before the term was coined. After a long period of disappointments (called the winter of AI), conditions are now ripe for AI to deliver on its initial promises thanks to: the tremendous increase in computing power, the explosion of data generation and collection; the advances in cognitive science (we cannot mimic the brain if we do not understand it sufficiently) and finally the significant increase in data scientists trained at universities around the world.

As a result, technologies today enable machines to perform the cognitive functions of sensations (by sensors); concept (by deep learning) and intent (by inference). Simply put, Artificial Intelligence is the science of self-learning software algorithms that execute tasks otherwise typically performed by humans. Over time, these machines will be equipped to make more decisions , helping us devote more time to higher-order thinking.

Artificial Intelligence is already all around us. On a daily basis, we use it without thinking about it anymore: Google search algorithms, Alexa and Siri to give voice commands to assist in our daily lives, Netflix and Spotify to determine our taste in film and music. Artificial Intelligence is already enabling more personalized medicine and treatment plans in healthcare. Facial, voice and fingerprint recognition are becoming more commonplace as well (e.g. Apple's new phones). In a foreseeable future, we are going to see more and more autonomous vehicles (first in closed settings and later on our roads).

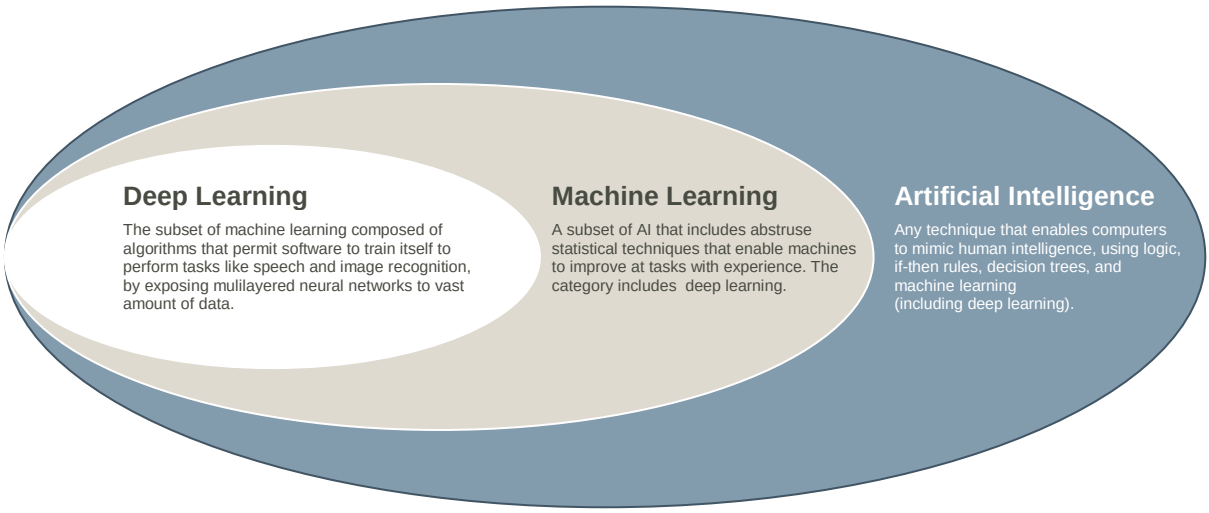
As Artificial Intelligence evolves to these next levels in the coming years, it will begin to have an exponential impact, especially in areas such as employment. Presumably, it will create public policy challenges; but looking on the bright side, this new set of technologies has the potential to also help us solve the complex problems that plague our society.

As shown later in this whitepaper, the investment community expects "Big Data and AI" to become the most influential/disruptive theme for the next five years.

But how do machines learn now? Until now, the best-known method to teach machines a concept is “deep learning”. Deep learning consists in feeding massive amounts of data to train a deep neural network (which consists of a set of algorithms modelled loosely after the human brain, designed to model complex phenomena). After the deep neural network completes its training, the learned concept could be retrieved and used for inference, which is basically the process of using in the digital world what the deep neural networks has learnt, for instance to recognize images, spoken words, a blood disease or suggest the shoes that someone is likely to buy next.

Artificial intelligence is what the steam engine was for the industrial revolution: It creates an ecosystem of skills, an industry for software/hardware and even a scientific discipline, fostering its growth and adoption.

Fig 1: A view on AI and its subsets



Source: CGS CIMB Research

Brice Prunas

Lead Portfolio Manager, Big Data Analysis
ODDO BHF Asset Management SAS

I What makes Artificial Intelligence unique to us

Artificial Intelligence is **a silent revolution that is going to reshape every industry and to profoundly transform the way we live**.

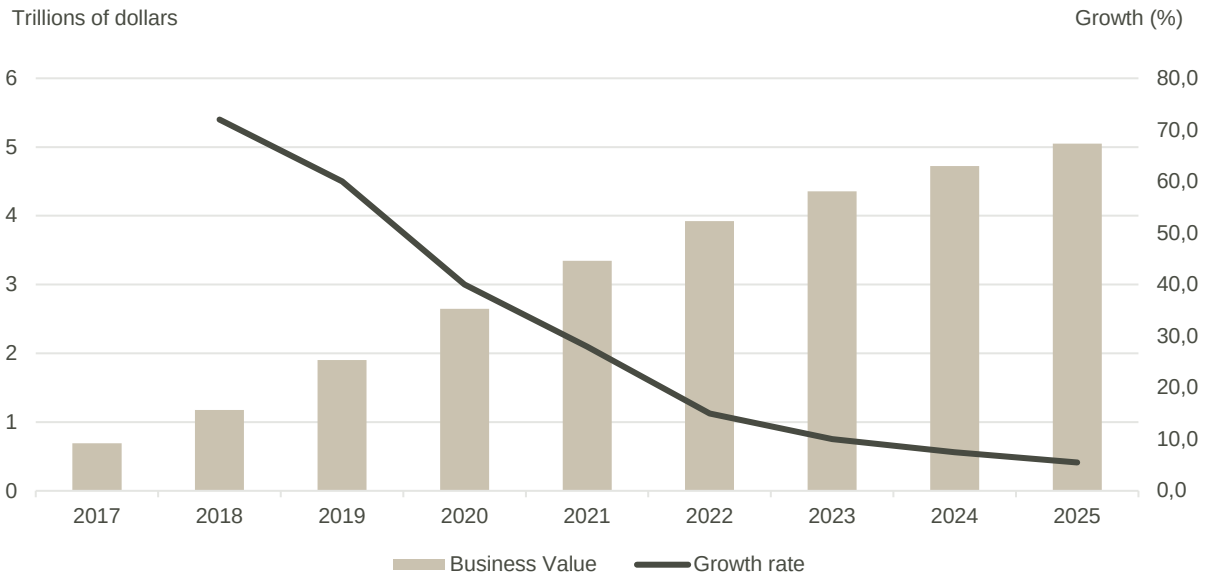
What we can clearly say is that the combination of four factors makes Artificial Intelligence (AI) a quite unique topic of analysis not only for researchers but also for investors:

- AI is poised to be a secular growth story
- AI pervades every sector of the economy
- AI has become a key engine for many other disruptive technologies
- Last but not least, AI is still in its “infancy”

AI is poised to be a secular growth story

According to Gartner, the forecast business value for AI is likely to multiply by a factor of more than 4 between 2018 and 2025 (from USD 1.18 Tr to USD 5.05 Tr). The fact that we are talking of trillions of USD shows the magnitude of the impact this new set of technologies is going to have on the economy. For us, this is the consequence of the twin status of AI: For one, it pervades all sectors and, secondly, it is a meta-technology that is at the core of several other disruptive technologies. Customer experience (as opposed to cost cutting that will come later) is likely to represent the brunt of AI business value, at least in the first years.

Fig 2: The business value of AI



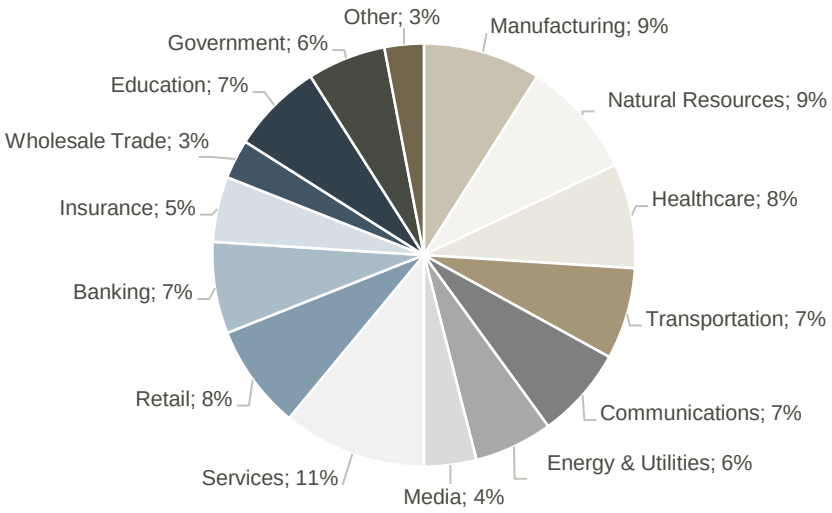
Source: Gartner 2018

AI pervades every sector of the economy

The ongoing Artificial Intelligence initiatives in the economy span a wide array of industry sectors. Actually, it is hard to find industries that are not launching innovation projects in that field. This seems to indicate that Artificial Intelligence projects could be a – or even the – source of competitive advantage for many industry sectors.

The 2018 Gartner AI Enterprise Perceptions, Plans and Implementation study (with 848 respondents) illustrates how Artificial Intelligence projects pervade all industries, as summarized below:

Fig 3: AI initiatives, split by industry sectors

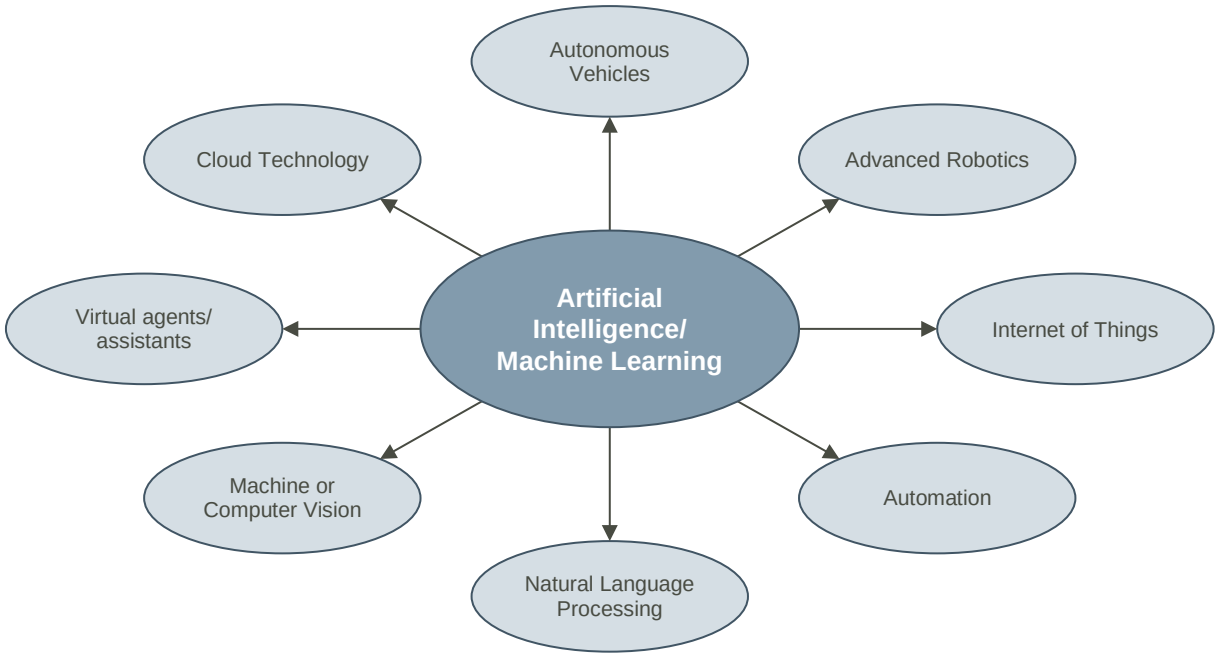


Source: Gartner (October 2018)

AI has become a key engine for many other disruptive technologies

Today we regard AI/ML (Artificial Intelligence/Machine Learning) as a key engine for several other disruptive technologies. We could call AI/ML a meta-technology. True, some of such technologies have existed before or even without the advent of AI/ML, but the latter has brought them additional reach and efficiency.

Fig 4: AI/ML as a key engine for several other disruptive technologies



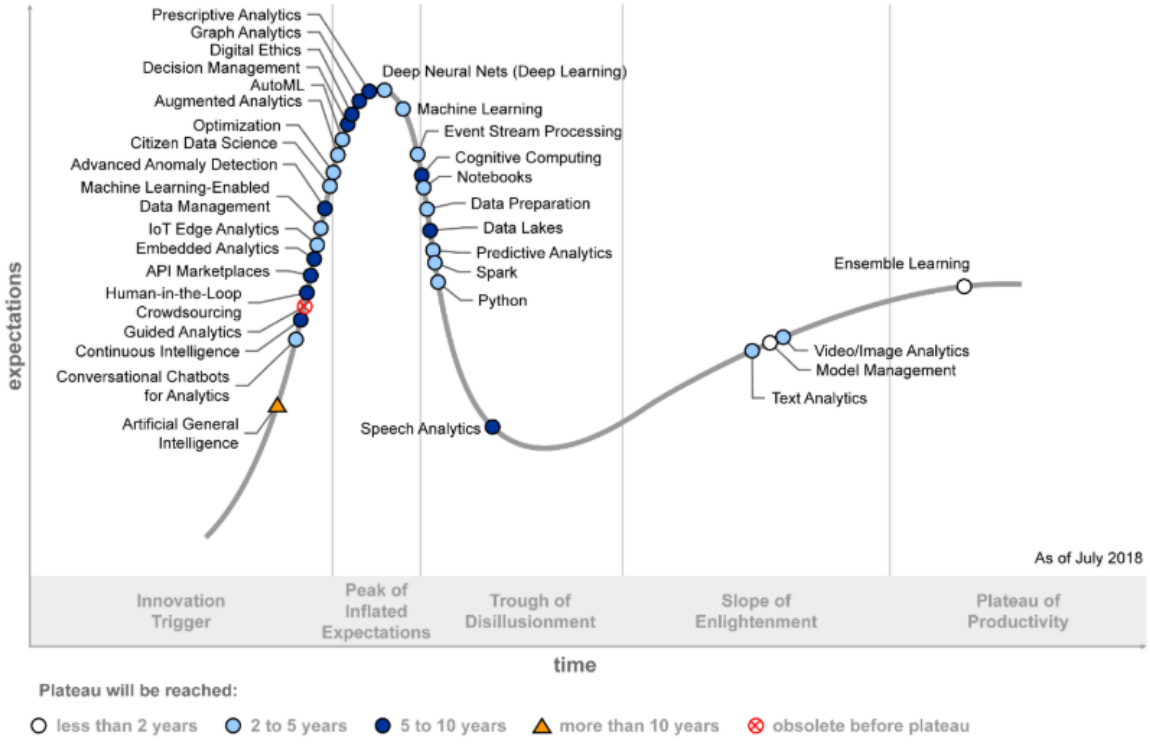
Sources: SG Cross Asset Research and Mc Kinsey

AI is still in its “infancy”

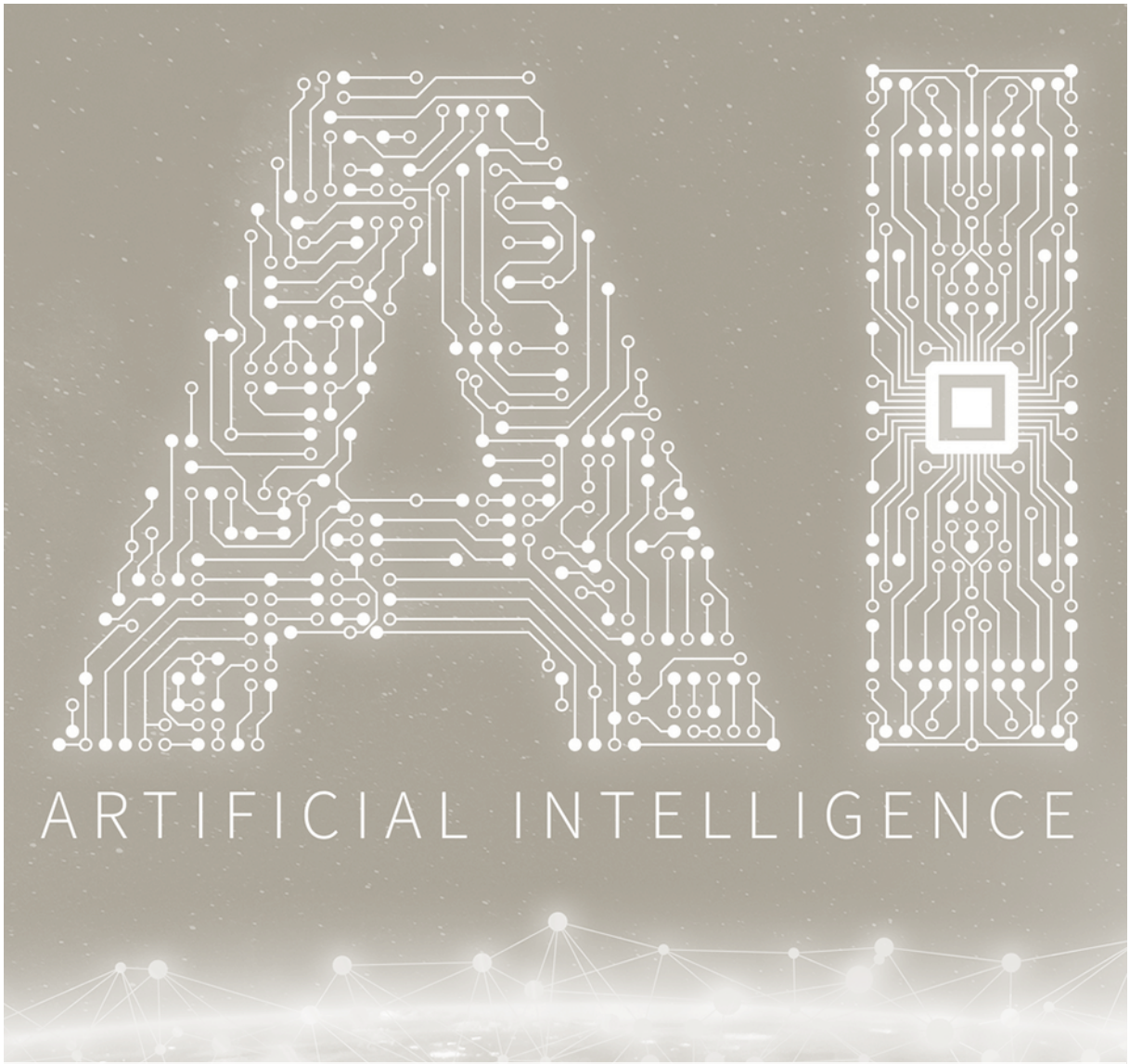
We believe it is of crucial importance to understand that Artificial Intelligence/Machine Learning is still in its early days. This is why we believe the challenges of investment professionals in the field of AI/ML to be as follows:

1. To think in a different time horizon: Some of these technologies can take several years to have a meaningful and sizeable business impact.
2. To differentiate between “hype” and “reality”: From an investor’s perspective, this means getting an understanding of how AI is going to drive sales, profit or could change the business model.
3. For every company considered, we need to wonder whether or not these companies have crossed their chasm (according to Geoffrey Moore’s theory, designed for technology products or services, there are which defines five stages of adoption of an innovation. After phase 1 called “the innovators” and phase 2 called “the early adopters” comes the chasm which is a period of vacuum and market disruption for the technology company before entering into phase 4 which seals the company’s breakthrough). So, all boils down to the central question of whether or not this is the time to invest.

Fig 5: The Gartner hype cycle for Data Science and Machine Learning 2018



Source: Gartner 2018



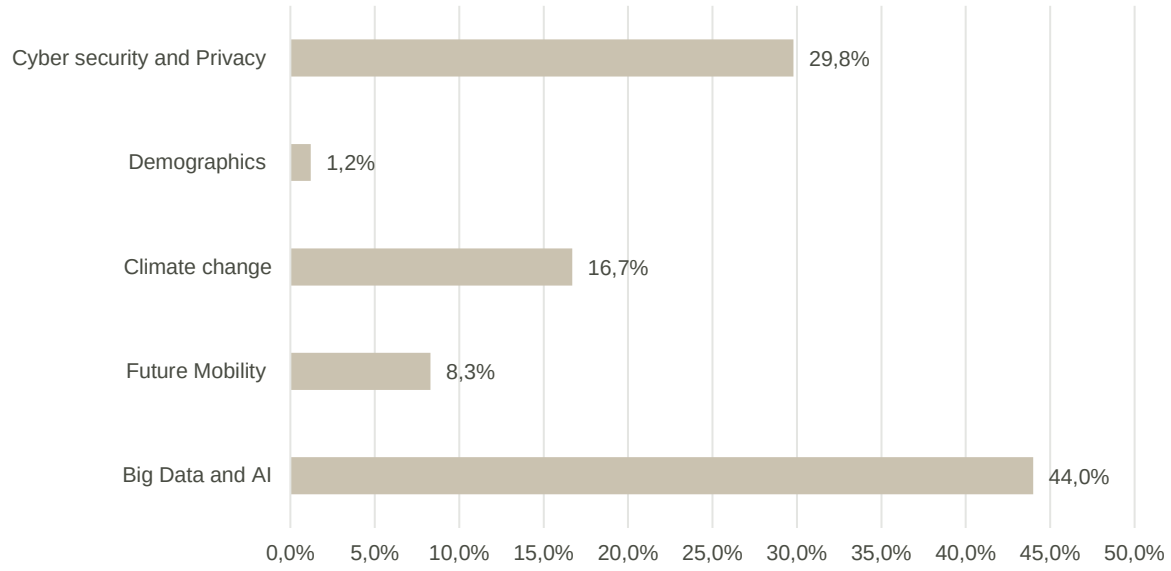
II How the investment community has been reacting so far to the breakthrough of AI

Before outlining our investment approach to the Artificial Intelligence theme in greater detail, it may be interesting to have a look at how the stock market and the investment community have reacted to the breakthrough of that theme.

While some might argue that Artificial Intelligence is all-pervading and will ultimately become the economy or the economic fabric itself, there seems to be a widespread **recognition of Artificial Intelligence as an investment theme**, be it on the private equity or on the asset management side.

More importantly, investors seem to believe that Big Data and AI are going to be the most disruptive/influential theme in the next five years (ahead of Cyber Security and Climate change):

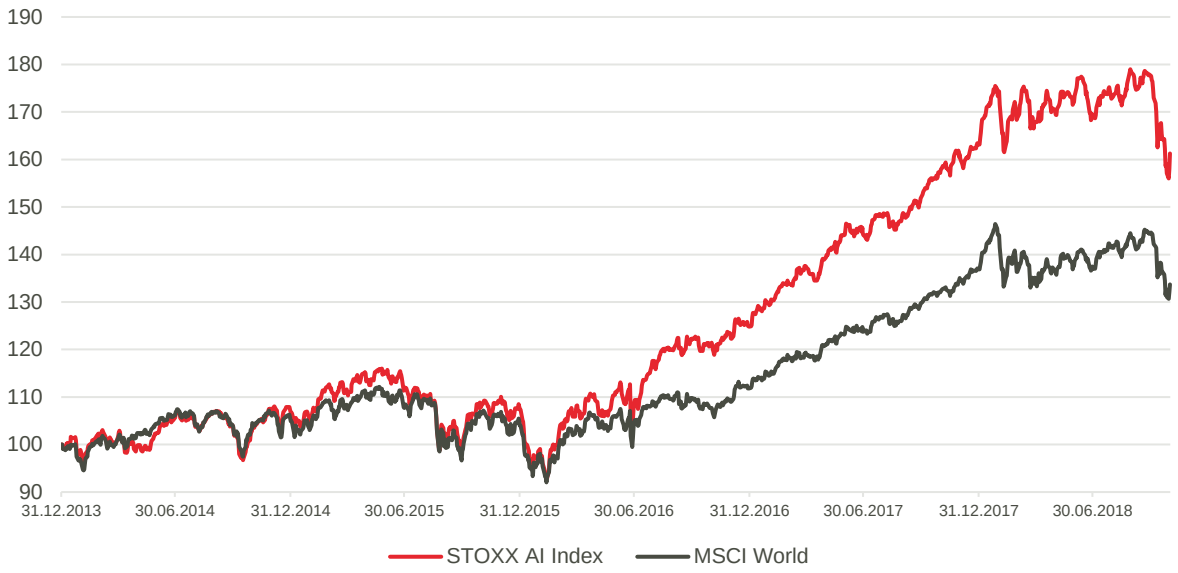
Fig 6: In your opinion, what will be the most disruptive/influential theme in the next 5 years?



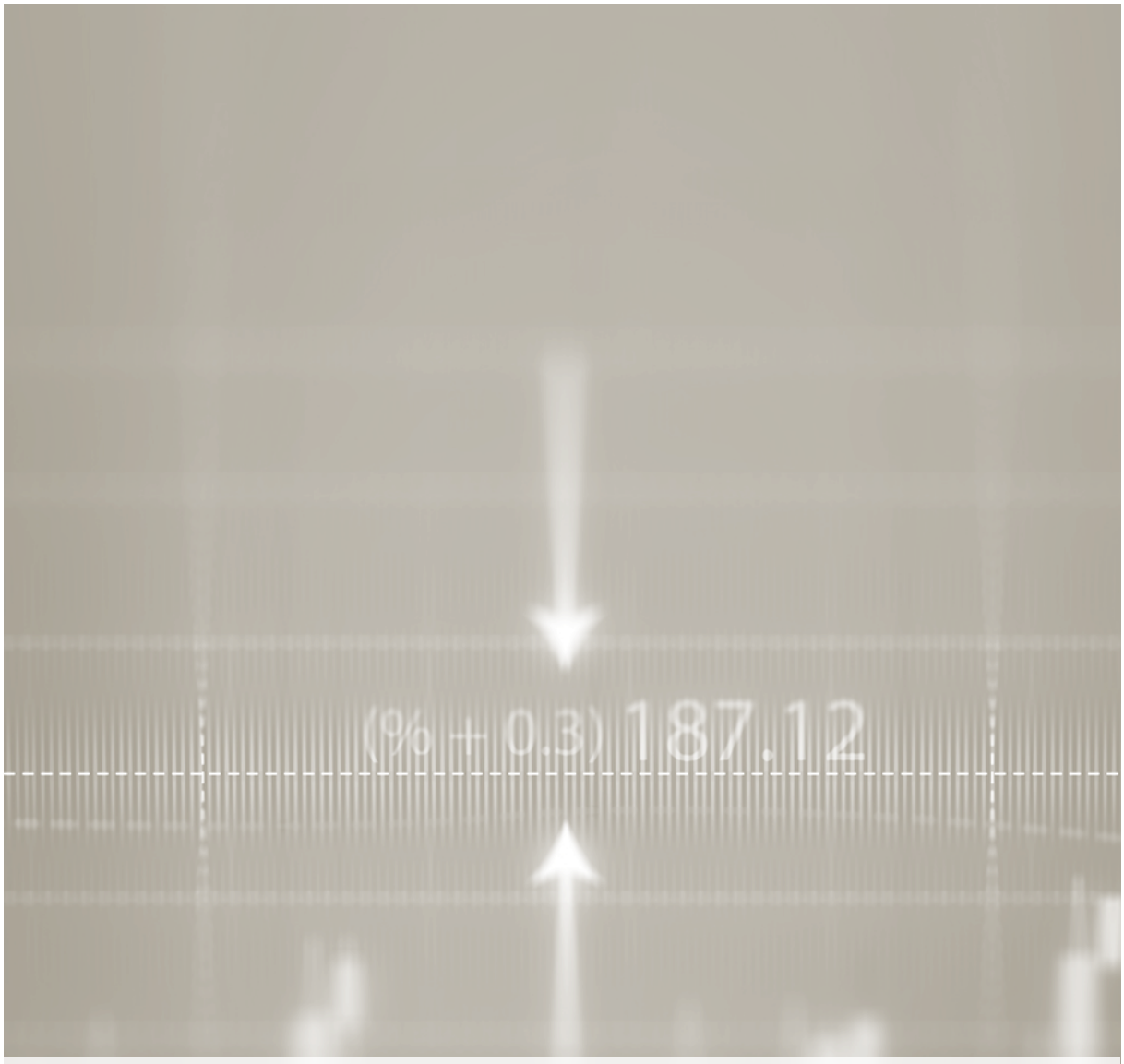
Source: Bank of America Merrill Lynch (November 2018)

Indexes have been created as well. The STOXX AI has already generated significant outperformance (vs MSCI World) since its launch end of 2013. It is noticeable that this outperformance has widened since mid-2016, coinciding with the time when it became possible to clearly identify some companies based on the Artificial Intelligence theme. In the future, we believe there will be increasing communication of listed companies on Artificial Intelligence. As investors, we see our role in distinguishing between hype and reality and in developing and understanding as to what extent Artificial Intelligence can really contribute to the shareholder value.

Fig 7: STOXX AI outperformance vs MSCI World



Source: Bloomberg, November 2018. Past performance is not a reliable indication of future returns and is not constant over time.



III Our investment approach to the Artificial Intelligence theme

A global approach is needed

It does not take long to understand that building a stock portfolio around Artificial Intelligence requires a global approach.

Actually, when considering the key pillars of the AI value chain (Data, Hardware/Semiconductors, Services, Software and Talent), it is easy to reach the following conclusions:

- The US are overwhelmingly dominant (particularly in the large semiconductor sector, but also in terms of services, software and pool of talents).
- China is a powerful contender in the AI arms race mainly as it is the region with the largest set of data generated and collected (another major pillar of the AI value chain). On the flip side, China is still lagging miles behind the US in that AI arms race given the very slow pace at which China builds its semiconductor industry. Indeed, Chinese semiconductor companies like SMIC are still running on trailing nodes and fail to build plants or production lines offering sufficiently high productivity standards. We believe it will take China more than a decade to build its semiconductor industry despite strong political backing.
- Japan holds more of an outsider status in AI thanks to its stronghold in robotics (which is their preferred approach to AI) and its reasonably good presence in the semiconductors and IT Services sectors. In our view, one of Japan's weakness is that people are reluctant to share data.
- Europe has some assets in the AI race (Software, IT Services, some specialized leaders in semiconductors), but suffers from its lack of coordinated effort and its inability to retain talents and to finance projects in early stages. Having said that, in some countries like France, we have recently observed some progress in the creation of a more positive environment for talent retention, start-up initiatives and *private equity* initiatives.

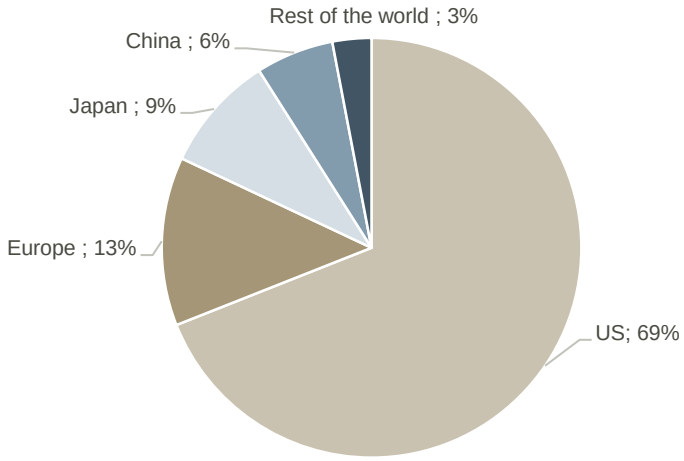
Fig 8: Artificial Intelligence taxonomy by geography

Seg-ments	Sub-segments	Elements	US	China	Japan	Europe	Comments
AI Data	Data from field	Data from users	Balanced	Strongest	Weakest	Weakest	China (and BAT particularly) has generated more data than anyone else
	Data from simulated environment	Data from labs,etc	Strongest	Balanced	Weakest	Weakest	US with more simulated data, China with more field data
AI Hardware	Silicon and platform	silicon for training, inference, platforms	Strongest	Weakest	Balanced	Balanced	US ahead in semiconductors. China weak. Japan and Europe have a decent semi indus-try.
	Systems	Autonomous vehicles, smart cities, robotics …	Strongest	Balanced	Strongest	Balanced	US and European car makers ahead on autonomous cars, China close on servers, Japan shines with robots
AI Services	Cloud	IaaS, PaaS, etc	Strongest	Balanced	Weakest	Balanced	US ahead, China and Europe cloud catching up
	Integrators	VARs, IT Services	Strongest	Weakest	Balanced	Balanced	US leads. Europe and Japan have a decent IT Services industry
	Telecom	Wireless, Wireline	Strongest	Strongest	Weakest	Weakest	Huawei, Nokia, etc.
AI Software	Infrastructure	Operating systems, security, etc	Strongest	Balanced	Weakest	Balanced	US owns the operating systems
	Applications	Mobile, consumer internet, Enterprise, etc.	Strongest	Balanced	Weakest	Balanced	US the strongest, Europe stronger in Enterprise and China is consumer apps
AI Talent	Hardware and software engineers, data scientists, AI researchers	Hardware and software engineers, data scientists, AI researchers	Strongest	Balanced	Weakest	Weakest	There is a global shortage of AI talents, but the US still has key experts while China is graduating a large number of PhDs and submitting more patents

Sources: UBS, ODDO BHF AM, November 2018

Based on above analysis, it would be realistic to expect the following geographical breakdown for an AI investment universe of listed assets.

Fig 9: Estimated geographic breakdown for an AI investment universe



Source: ODDO BHF AM, November 2018

One might notice the relative disconnect between China's power in the AI arms race and its rather modest presence in our Global Equity investment universe. The answer to this paradox lies in the fact that the Chinese AI superpower is built on non-listed assets rather than on listed ones. However, Chinese economy is home to some leading companies like Baidu with multi-leader status in AI; or even Ping An (Insurance) that has managed to turn AI into a competitive advantage by integrating it at the core of its key processes.

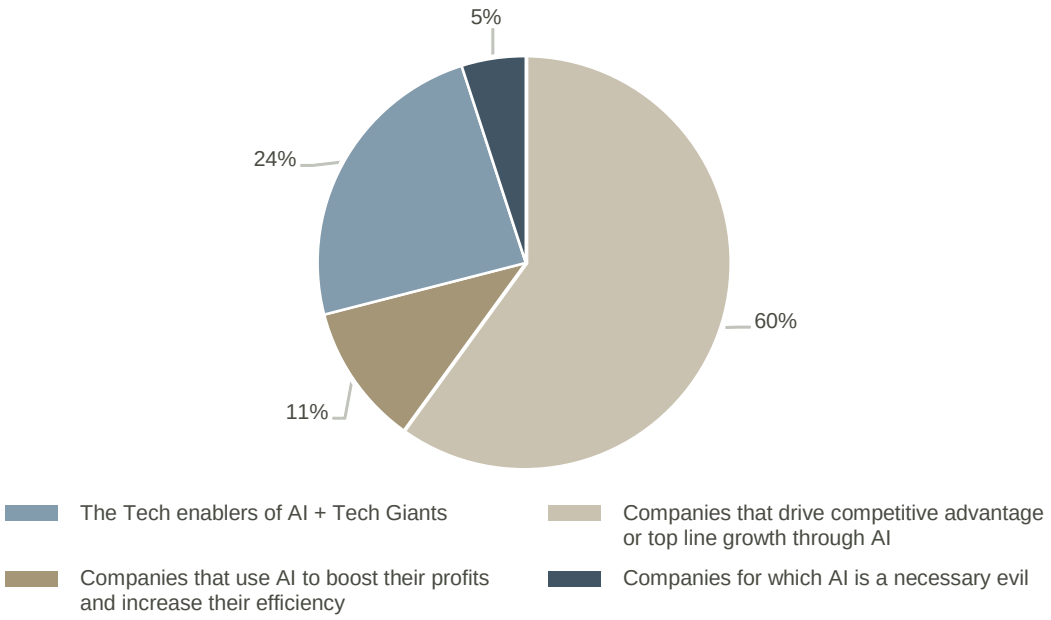
Our global investment universe: Five groups of companies

We have split our global investment universe into five groups of companies. Each of these groups includes companies with homogeneous features in terms of how their business model is impacted by AI:

- Technology enablers of Artificial Intelligence
  (semiconductors being here the most represented sector)
- Tech giants (or “all-rounders” of AI)
- Companies that use AI to drive their competitive edge or their top line growth
- Companies that use AI to boost their profits and increase their efficiency
- Companies that see AI as a “necessary evil” (mainly the car making industry in our view but not their suppliers)

Here again, we would like to give a rough estimate on how our global universe would breakdown when applying this taxonomy:

Fig 10: An estimated sector split for an AI investment universe



Source: ODDO BHF AM, November 2018

For those interested in learning more about our assessment of these 5 sub-categories, please find below a more detailed outline of our taxonomy, with some examples of associated companies[1]:

1. Technology enablers of Artificial Intelligence:

The development of AI has been largely propelled by the exponential growth of computing power of processors and the explosion of data. As a result, we will find in that category:

- **Semiconductor companies**, be it suppliers of processors, (Nvidia, Intel, AMD…) or application-specific integrated circuits/ASIC (Broadcom, Mediatek), or even suppliers of the critical components of a chip (Texas Instruments, Analog Devices, STM, Infineon…).
- **Suppliers of the semiconductor industries**, e.g. companies providing the equipment for this new breed of chips (Applied Materials, Lam Research or even ASMI and ASML in Europe; Tokyo Electron in Japan), the factories of the fabless companies (like TSMC) or even the design/EDA companies (like Synopsys, Cadence).
- **Cloud native software companies** using AI to help their clients to make the most of their data by issuing predictions about future trends (Salesforce with Einstein, Workday with HR predictive analytics).
- **AI application specific leaders such as Nuance**, a leading provider of voice recognition and natural language understanding solutions that are widely used in the healthcare sector (hospitals, clinic). Another example is Ambarella and its leading technology of computer vision that can be used in Autonomous Driving or IP security cameras.
- **Disruptive storage companies (Pure Storage, Nutanix)** but also incumbents like Netapp offering innovations to solve the issue of bottlenecks (at storage level) resulting from the two key features of Artificial Intelligence and Machine Learning (fast processing with GPU and usage of large data sets).

2. The Tech Giants (or “all-rounders” of AI):

Be it FAANG (Facebook, Amazon, Apple, Netflix Google) or BAT (Baidu, Alibaba, Tencent), also called hyperscale vendors (when characterizing these companies by the huge computing infrastructure they need to process these large sets of data) – all these companies are by far the largest CAPEX spenders in Artificial Intelligence. According to McKinsey, these companies invested between USD 20 bn and USD 30 bn in 2016, out of a total of USD 26 bn to USD 39 bn CAPEX spent on AI (with start-ups accounting for the rest). Most of such CAPEX were spent internally (R&D and deployment), but in some cases also on M&A – a practice known as “acqui-hiring” for sums that may

[1] The companies mentioned below should not be considered as investment recommendations

well reach USD 5 million to USD 10 million per person. As a result, these Tech giants are today present in many different segments of AI. To give a few examples:

- **Amazon:** The online retail giant offers both consumers and businesses AI products and services. Amazon Echo brings artificial intelligence into the home through the intelligent voice server, Alexa. On the business side, Amazon Web Services allow developers to add intelligence to their applications through an API call to pre-trained services (Amazon Lex, Amazon Polly, Amazon Rekognition), saving them the need to develop and train their own models. On its core business, Amazon has derived tremendous value from its USD 775m investment in Kiva, a robotics company that automates picking and packing.

- **Google has even a broader spectrum of Artificial Intelligence capabilities.** Google Home similarly brings artificial intelligence to the home. On the business side, the Google Cloud Platform (GCP) provides developers with AI building blocks (especially for developers with limited machine learning expertise), AI solutions and an AI platform (serverless infrastructure for data scientists). Google has developed its own ASIC (Application Specific Integrated Circuit) chip for AI that is called TensorFlow (A tensor processing unit/TPU that competes with the GPU). Last but not least, among Google's "other bets", we can find "Waymo" which is one of the most advanced and comprehensive self-driving cars initiatives in the world.

- **Baidu:** In November 2018, Baidu held its Baidu World conference with a key theme "yes AI Do". The Chinese giant continues to focus on the application of AI in various key strategic areas, including autonomous cars (Appolo), smart operating systems (DuerOS) and AI clouds. Baidu has recently announced plans to jointly develop level 4 autonomous driving passenger cars with Volvo. The DuerOS total installed base has meanwhile reached 150 million users, registering 35 million monthly active users in October 2018.

3. The companies that use AI to drive their competitive edge or their top line growth:

Being the next digital frontier, AI can easily become the source of competitive advantage, particularly for early adopter companies putting AI at the core of their client relationship or product innovation. Some examples:

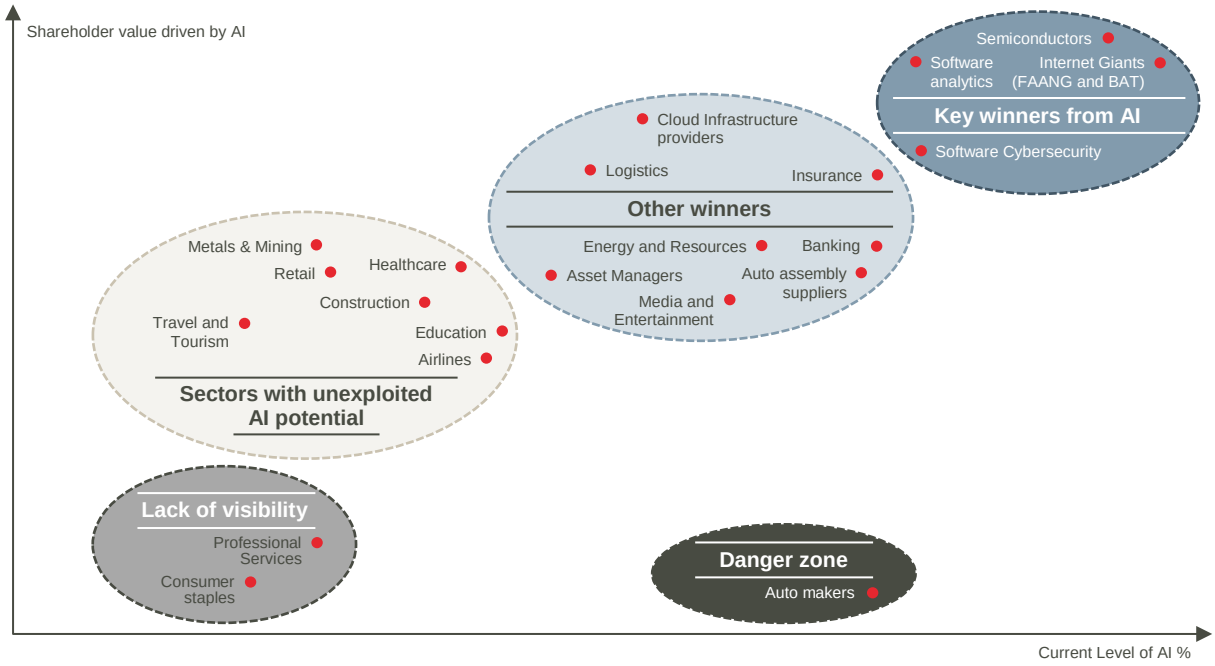
- **Streaming companies:** For **Netflix**, helping clients to quickly find the desired content is critical. The US streaming company has achieved compelling results from the algorithm it uses to personalize recommendations for its circa 140 million subscribers worldwide. **Spotify** also employs Big Data and AI technologies in many ways, e.g. by providing their subscribers with a personalized play list on a weekly basis or by giving artists and labels access to their customers' large data sets via a mobile app.

- **Healthcare companies:** There is a wide spectrum of AI applications in healthcare. Beyond the emergence of chatbot, robots, speech recognition or virtual assistants as tools to interact with the

patients or to make doctors' life easier, we believe there is a race among the pharma labs to better integrate AI/ML technologies so as to cure diseases (like certain forms of cancers) or to detect tuberculosis or brain bleeds. However, this part of the Artificial Journey is still years down the road as no pharma lab has not yet been able to announce the development of a new widely used molecule thanks to AI.

- **Retailers:** In retail, Artificial intelligence is being applied in new ways across the entire product and service cycle. Among these various applications, several stand out for us:
  - IBM Watson helps consumers to decide which kind of article is good for them. As an example, **North Face** has adopted IBM Watson's cognitive computing technology to help consumers determine what jacket is best for them, based on variables like location and gender preference. For instance, hiking in Iceland in October and commuting in Toronto in January will yield different results.
  - **Sephora** has an exclusive machine learning-driven, in-store product that scans the surface of your skin to provide a personalized foundation and concealer shade recommendation.
  - As an early adopter of machine learning, **Walgreens** uses information technology to tailor inventory for anticipated flu outbreaks and to reduce overstocks by predicting which stores will best sell promotions.
- **Apple:** There are many areas where Apple has used Artificial Intelligence. We just want to mention one field where Artificial Intelligence technologies enable Apple to get an edge on its competition: facial recognition (through 3D sensing technologies) for smartphones. While the Android camp is trying hard to catch up with Apple in this regard, we believe Apple still has an edge thanks to its value chain of suppliers (including STM). For the typical high end consumers of smart phones, this capability can make the difference in the buying decision and enables Apple to drive up its ASP (Average Selling Price).

Fig 11: ODDO BHF's proprietary segmentation of sectors regarding to the AI theme



Source: ODDO BHF AM, November 2018

4. The companies that use AI to boost their profits and increase their efficiency:

- **Financial Services:** This is probably the sector where the caricatural image of AI/ML replacing human jobs is applicable. Over the past few quarters, we have seen Wall Street banks intensifying their investments in AI either through expensive hiring (from Google for example) or through taking stakes in start-ups. AI can be used in many areas of the banking industry like risk assessment (e.g. in credit cards management), fraud detection and ,management (e.g. in the loan business), financial advisory (robo-advisors), trading (machine can be taught to observe patterns in past data and predicts), managing personal finance. As a result, it would not be a surprise to find in an Artificial Intelligence fund, and under certain conditions, names like JP Morgan, Bank of America, CitiGroup, Morgan Stanley or Goldman Sachs that have led the race in terms of AI investment. In the insurance sector, a Chinese leader like Ping an has put Artificial Intelligence at the core of its processes (examples can be found in the car insurance business, where in case of a car accident, you can use the Ping an app to take a photo of the damaged car that will be subsequently cross-referenced in the database with millions of photos to qualify the type of damage of the car).

- **Airlines:** Interesting enough, the airline industry looks set to benefit from the use of Artificial Intelligence to automate processes and boost productivity. Several initiatives have already been launched: **Delta Airlines** reported an investment in four automated self-service bag checking kiosks that will incorporate facial recognition technology, starting with Minneapolis International Airport. Southwest Airlines has been transparent about using machine learning to improve

operations (time series analysis to identify potential flight glitches). More ambitious projects aim at using machine learning so as to save on fuel. As of today, it would be fair to say that we are just in the very early days of this technology in the airlines industry.

- **Manufacturers:** Manufacturing is another sector rife with examples of industry shaping AI innovations.
  - Computer vision is a good case in point (even the most eagle-eyed human inspector would fail at finding flaws half the width of a human hair. But a machine equipped with a camera many times more sensitive than the naked eye won't miss a beat. The Japanese robot vendor Fanuc seems to have developed an interesting technology in that field called iRVision).
  - Digital twins have become a very important manufacturing process that pairs the virtual and the physical world. This process is instrumental for the monitoring of systems, for the preventing of downtime and the forecasting of the future by using simulations. The digital twins leverage the Internet of Things (IoT) but requires the skills of machine learning and artificial intelligence. Airbus use "digital twins" for the flight-test of its aircrafts before selling them. Every aircraft is now equipped with more than 3000 low-cost sensors (in the past each of these sensors cost between EUR 2000 and 3000 per unit). A company like Mitsubishi has digitalized all its processes in one of its Japanese plant thanks to digital twins.

5. The companies for which AI is a "necessary evil":

Carmakers are probably one of the only sectors where AI (in particular with the development of Autonomous Driving) is actually a "necessary evil" with uncertain returns. Basically, carmakers are forced to pour money in Autonomous Driving to follow the competition but shareholder returns are hard to find and are years down the road. On top of that, AI threatens to bring in new players (ex Waymo that belongs to Alphabet) and change the business model of carmakers. First movers in that space (Waymo for Alphabet, GM through Cruise, or BMW in Europe) may meet a slightly better fate but we doubt this is going to be a winner-takes-it-all business model. For automotive suppliers, the business case of AI/Autonomous Driving may well be a little less glum as we see it as a chance for them to enhance the value/the ASP of their parts e.g. by embedding a higher-order semiconductor content into it. Some autonomous luxury cars can embed today not less than 45 semiconductors (sensors, Radar, Lidar).

Focus on the most represented sector in the AI global investment universe: Semiconductors

It is hard to envisage Artificial Intelligence without semiconductors. The link between the two are manyfolds:

Processors:
The approach taken to AI deep learning is similar to human cognition: a computer learns through exposure. In more practical terms, a neural network is fed with thousands of training images that are processed via multiple layers in order to build experience and knowledge. At the end of this process, the computer should be able to flawlessly tell the difference between two images that are initially easy to confuse (e.g. due to the astonishing similarity between a small dog's face and a cupcake). There is a current fascinating debate about which technology of chips is going to win the artificial intelligence race. While the Graphics Processing Units called GPU (Nvidia) seem to lead the race (on the training side of deep learning) thanks to their parallelization allowing fast and complex processing, there are alternative technologies that can be of interest: for example the TPUs (Tensor Processing Units) that are Application Specific Chips (ASIC), the most famous one being the one pushed by Google: the tensorflow. Another competing processing technology vying with GPU and TPU is FPGA (or Field-Programmable Gate Array) pushed by companies like Xilinx or Intel probably have their role to play (particularly for the inference side of deep learning).

Equipment:
To build the complex artificial intelligence chips (some of them housing billions of transistors on a surface of just a few nanometers), you need very complex equipment and layers of etch & deposit (that are provided by firms like Applied Materials, Lam Research, Tokyo Electron), but also lithography (where you find the overwhelming dominant ASML).

Power Semis:
To learn, networks need to be able to sense. Local edge devices include sensors, cameras, data collectors. These devices are the eyes, ears and hands of the neural networks. Clearly, a more sophisticated approach to power design is going to be required by Artificial Intelligence. Companies like Infineon, NXP Semiconductors, Texas Instruments are leaders in that space.

Memories:
AI is likely to create an increasing demand for new memory types that are fast at reading and writing, and non-volatile at the same time. Such new types of memory are PCM, MRAM and RRAM. They are going to offer challenges but also market opportunities for the oligopolistic vendors that are Samsung, Hynix, Micron, Toshiba and Western Digital.

Glossary

Artificial Intelligence (AI): Artificial intelligence, a branch of computer science dealing with the simulation of intelligent behaviour in computers.

Algorithm: In mathematics and computer science, an algorithm is a self-contained sequence of actions to be performed. Algorithms perform calculation, data processing, and/or automated reasoning tasks.

Augmented reality (AR): A live direct or indirect view of a physical, real-world environment whose elements are augmented (or supplemented) by computer-generated sensory input such as sound, video, graphics or GPS data.

Big Data: A term for data sets that are so large or complex that traditional data processing applications are inadequate to deal with them.

Computer vision: An interdisciplinary field that deals with how computers can be made for gaining high-level understanding from digital images or videos.

CPU: A central processing unit (CPU) is the electronic circuitry within a computer that carries out the instructions of a computer program by performing the basic arithmetic, logical, control and input/output (I/O) operations specified by the instructions. The computer industry has used the term "central processing unit" at least since the early 1960s.[1] Traditionally, the term "CPU" refers to a processor, more specifically to its processing unit and control unit (CU), distinguishing these core elements of a computer from external components such as main memory and I/O circuitry. The main CPU architecture is the X86 from Intel.

Data mining: The computational process of discovering patterns in large data sets involving methods at the intersection of artificial intelligence, machine learning, statistics and database systems.

Data science: Also known as data-driven science, is an interdisciplinary field about scientific processes and systems to extract knowledge or insights from data in various forms, either structured or unstructured, which is a continuation of some of the data analysis fields such as statistics, machine learning, data mining, and predictive analytics, similar to Knowledge Discovery in Databases (KDD).

Deep learning: Deep learning *(*also known as deep structured learning or hierarchical learning*)* is part of a broader family of machine learning methods based on learning data representations*,* as opposed to task-specific algorithms*.* Learning can be supervised, partially supervised or unsupervised.

DRAM: Dynamic Random access memory is a type of random access memory that stores each bit of data in a separate capacitor within an integrated circuit. It is a volatile memory, which means it loses its data once power is switched off. It is mostly used to run operating systems.

Gartner: Gartner is the world's leading research and advisory company. They are widely used in the field of technologies and are famous for their estimates of market size as well as for their magic quadrant applicable on any segment.

GPU: Graphic processing unit is a specialized electronic circuit designed to rapidly manipulate and alter memory to accelerate the creation of images in a frame buffer intended for output to a display device. GPUs are used in embedded systems, mobile phones, personal computers, workstations, and game consoles. Modern GPUs are very efficient at manipulating computer graphics and image processing, and their highly parallel structure makes them more efficient than general-purpose CPUs for algorithms where the processing of large blocks of data is done in parallel. In a personal computer, a GPU can be present on a video card, or it can be embedded on the motherboard or—in certain CPUs—on the CPU die. Main GPU makers are NVidia and AMD.

Inference: Inference happens after training (and can't happen without it). Just like a human education, the goal is to learn to do a job. This job phase is called inference, regardless of whether the trained neural network learned how to recognize images, text, or cancer cells. Inference essentially takes real-world data and quickly comes back with a prediction. The importance of this phase is to minimize the scope of the model by removing any parts not necessary to make this prediction. Other layers are combined if the impact is negligible. These two processes are similar to image or video compression where the goal is to minimize file size while having the smallest impact on quality.

IoT (Internet of Things): this is a network of devices, vehicles, and home appliances that contain electronics, software, actuators and connectivity which allows these things to connect, interact and exchange data. IoT can be found in the consumer space (e.g. wearables, smart bikes, etc.) or in the industrial space (digital twins with Siemens and GE and sensors all over the shop floors).

Lithography: The transfer of a pattern or image from one medium to another, such as from a photomask to a wafer using a stepper.

Machine learning: Machine learning is the process by which AI uses algorithms to perform artificial intelligence functions. It's the result of applying rules to create outcomes through AI. This is a subfield of computer science that gives computers the ability to learn without being explicitly programmed.

Machine vision (MV): The **t**echnology and methods used to provide image-based automatic inspection and analysis for such applications as automatic inspection, process control and robot guidance, usually in Industry.

Microprocessor: An integrated circuit that contains arithmetic, logic and control circuitry in a single package.

Natural Language Processing (NLP): A field of computer science, artificial intelligence and computational linguistics concerned with the interactions between computers and human (natural) languages and, in particular, concerned with programming computers to fruitfully process large natural language corpora.

Neural networks: A computational approach, which is based on a large collection of neural units, loosely modeling the way a biological brain solves problems with large clusters of biological neurons connected by axons.

Sensor: A sensor is a device, module, or subsystem whose purpose is to detect events or changes in its environment and send the information to other electronics, frequently a computer processor.

Tensor Processing Unit (TPU): A TPU is an AI accelerator application specific integrated circuit (ASIC) developed by Google specifically for neural network machine learning.

Training: At a high level, the goal artificial intelligence is to replace algorithms that are explicitly programmed by people with algorithms that learn on their own. Hand-coding routines is highly-inefficient, error-prone and not adaptable to new information. Instead, deep learning is used to learn features & patterns that best represent data automatically. The process by which these systems learn is called **Training**. Training is the phase in which the computer essentially tries to learn from your data. Let's use an example: Think of the almost infinite number of rules required to describe the nearly infinite ways to compose a handwritten letter *A*. With deep learning, we can simply "show" the computer thousands (or millions) of letter *A*'s until the computer "learns" how to best describe what an *A* looks like. After the computer learns how to identify an *A*, we can then ask it to do exactly that. This phase is called **Inference**. **Training** is computationally very expensive and is best accelerated with GPUs. Using even a small dataset, the time taken per epoch (one complete pass through all of the training samples) can be reduced from 3-4 minutes on a CPU to just a few seconds when using a GPU.

Virtual reality (VR): A computer technology that uses virtual reality headsets or multi-projected environments, sometimes in combination with physical environments or props, to generate realistic images, sounds and other sensations that simulate a user's physical presence in a virtual or imaginary environment.

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