

SECTOR IN-DEPTH

8 February 2018

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Cross-sector - Artificial intelligence

As AI goes mainstream, its potential to reshape sectors still remains years away

Summary

- » **Considerable progress over the past five years.** Artificial intelligence (AI) is a broad concept covering many different applications and models. After decades of slow progress, AI technologies have advanced meaningfully in recent years on the back of increases in computing power, large and growing datasets and improvements in underlying algorithms. Companies from large multinationals to small startups are investing heavily, and real-world applications are becoming mainstream. While there are many applications of AI, high tech and media, autos, financial services and manufacturing are particularly intense users at this stage. (Industry case studies begin on page 8.)
- » **Big tech firms have built a strong position.** The largest technology firms such as Google parent [Alphabet Inc.](#) (Aa2 stable), [Amazon.com Inc.](#) (Baa1 positive) and [Microsoft Corp.](#) (Aaa stable) account for a large share of the recent increase in AI investment, and have the potential to capture an outsized share of the value that AI will generate. While these firms' formidable financial resources enable them to develop new capabilities and applications through in-house R&D as well as acquisitions, they also have meaningful strength in collecting, analyzing and, ultimately, "monetizing" data, which will only be enhanced through AI.
- » **AI could change competitive dynamics in several sectors.** Many of today's AI applications are focused on enhancing efficiency and profit margins through automating routine tasks, optimizing R&D, reducing error rates or improving forecast accuracy. Those that provide value for customers can also increase revenues. The firm-level impact of AI will depend on each competitor's strategic vision for best utilizing the technology's capabilities and financial resources to invest in systems and people. It will likely be some time before the implications for competition within sectors become clear.
- » **AI could affect human resource allocation within firms and across countries.** Some AI applications will likely displace some types of human labor, while necessitating skills retraining of significant segments of the labor force. Countries with lower-cost, skilled labor could lose their comparative advantage in manufacturing that can be facilitated by robotics. Similarly, companies that provide human labor to do tasks that ultimately can be automated—call-center operators, for example—could face a vastly different competitive landscape. On the other hand, some have argued that increased task complexity related to AI could increase wages for skilled human workers, but this remains to be seen.

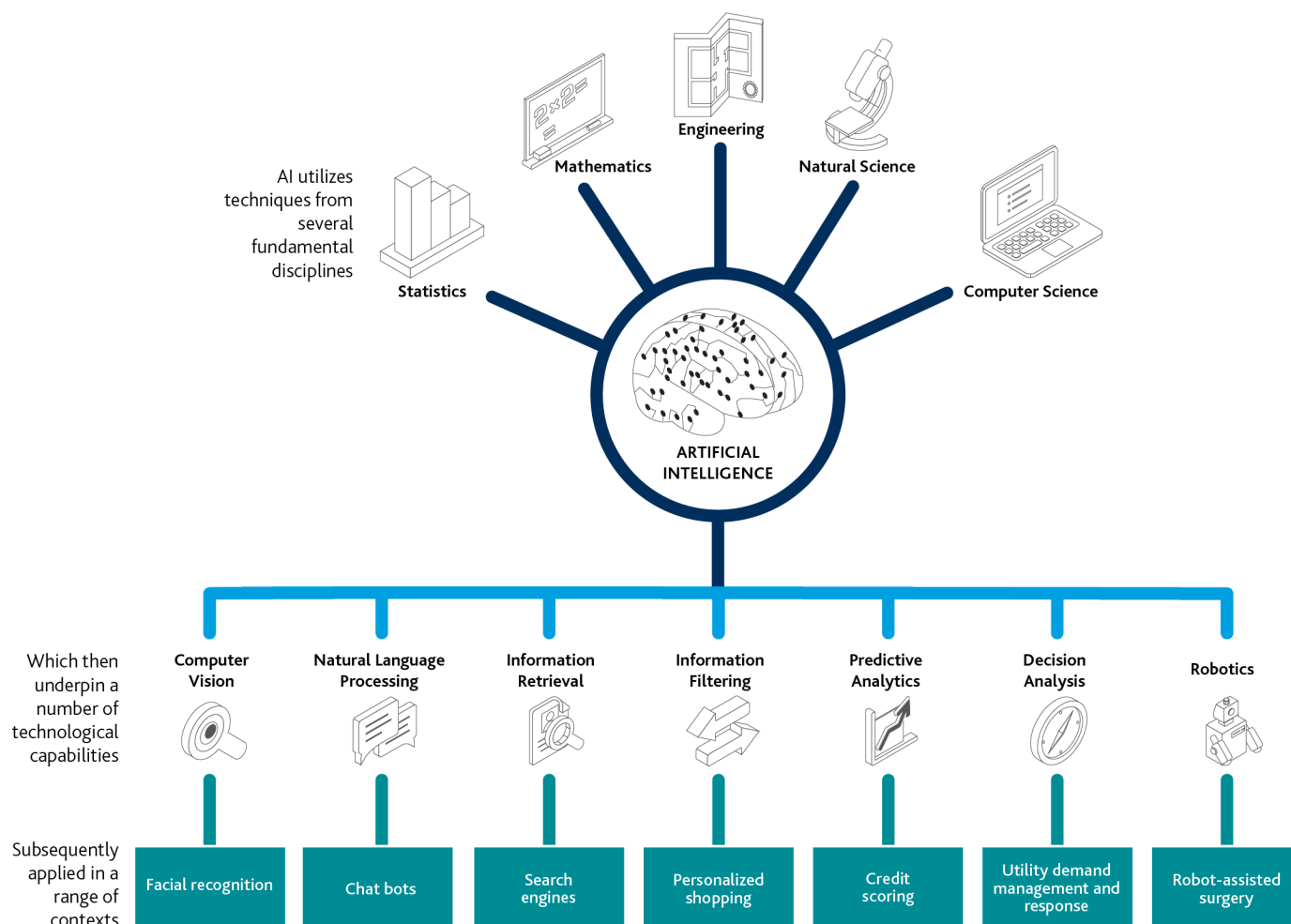
Artificial intelligence technologies have made considerable progress over the past five years

While artificial intelligence (AI) is often thought of as a single technology, the term encompasses a collection of advanced technologies that together and separately enable machines (computers, robots) to function “intelligently,” or in other words to perceive their environment and adapt themselves to achieve a certain goal or discover a certain solution. AI can be applied in a wide range of contexts, as shown in Exhibit 1.

Exhibit 1

The AI concept covers many different technologies

Overview of AI origins and applications



Source: Moody's Investors Service

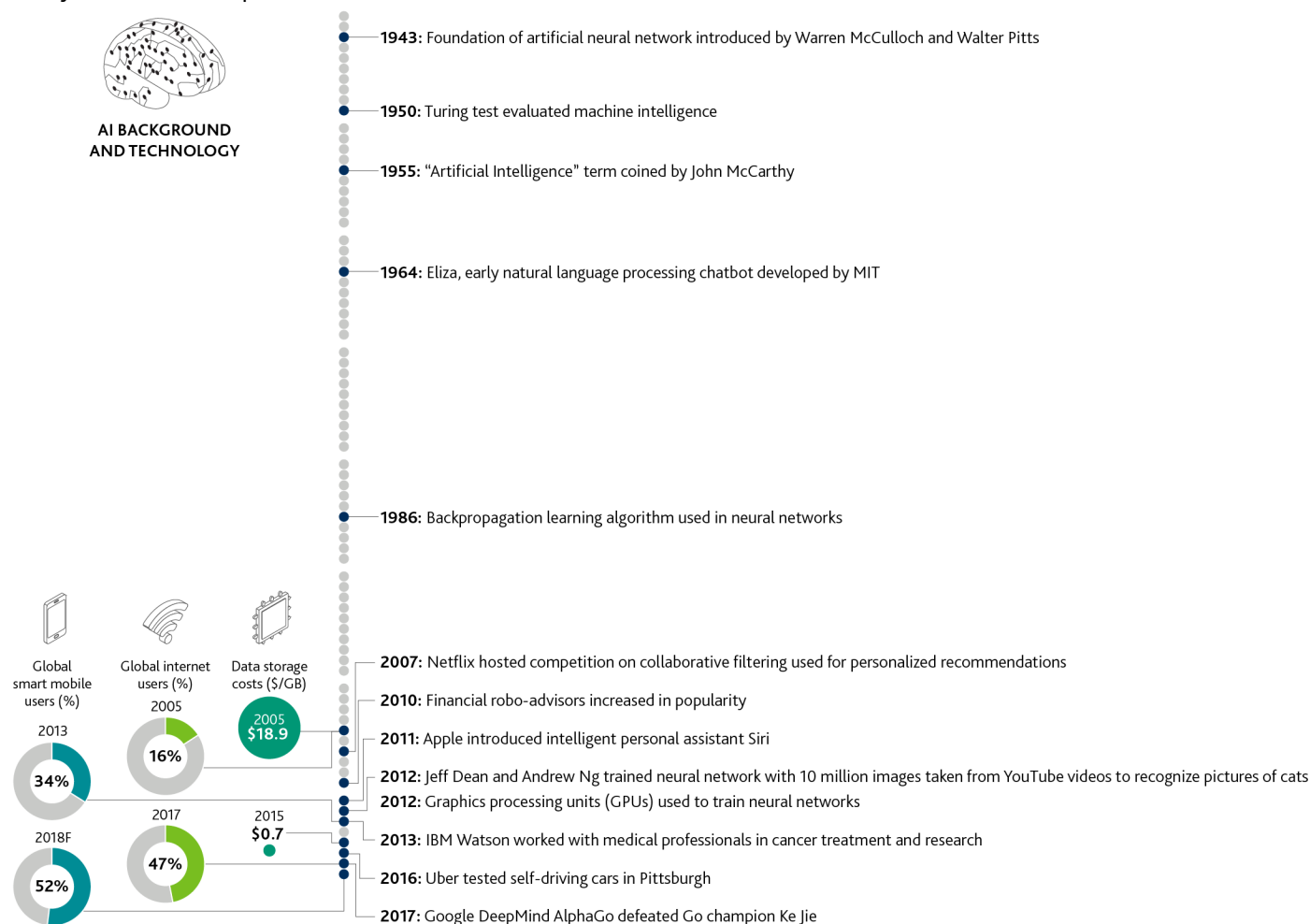
Although AI is attracting a lot of attention today, it is not a new concept: The idea of computer- or machine-based intelligence dates back to 1950, when the British mathematician Alan Turing posed the question of whether a machine can exhibit intelligent behavior indistinguishable from a human. That said, progress was relatively slow until about 2010 (see Exhibit 2).

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Exhibit 2

Progress has accelerated since 2010

History of notable AI developments



Source: eMarketer, Internet Live Stats, Moody's Investors Service

AI development has gained exponential momentum across a wide range of industries and sectors in recent years on the back of faster computing power, larger datasets and improvements in underlying algorithms. Firstly, graphics processing units, or GPUs, today allow more complex computations than previous microprocessors. In addition, the ever deepening integration of the internet into people's lives – most recently spurred by the ubiquity and power of mobile devices – has led to an explosion in the amount of high-quality data than can be used to develop AI applications. Lastly, much academic research interest has been directed toward machine learning, creating momentum in the development of algorithms, building on the progress made in the 20th century.

At the same time, companies have been investing heavily. The consulting firm McKinsey & Co. estimates that AI-related investments and M&A trebled between 2013 and 2016, reaching a total of \$26 billion-\$39 billion, including \$20 billion-\$30 billion spent by the largest technology firms alone.

Effects on competition and credit will materialize over time and differ among sectors and companies

Overall, AI provides opportunities for firms to cut costs and optimize capital allocation, which can strengthen creditworthiness. AI technologies can automate repetitive tasks such as answering customers' requests or analyzing legal documents. They can also yield substantial productivity gains by optimizing research and development spending. Pharmaceutical companies could, for example, use AI-powered applications to predict how molecules will behave and how likely they are to make a useful drug, thereby saving time and money on testing. Additionally, by learning from past performances and analyzing current operating conditions, AI can help improve
















forecasts. For example, packaged goods manufacturers and retailers will be able to more accurately forecast product demand and, therefore, their inventories.

Application of AI can also raise earnings by increasing revenues. Through the analysis of large amounts of traditional and nontraditional (for example, that derived from social media usage) data, machine learning applications can help identify customers' future demands, and thereby create more successful products, sold at a price that AI will help to set. The technology is also being used to optimize marketing spending and enhance user experience by providing targeted advertisement and product recommendations. In addition to these identifiable sources of revenues, AI could lead to the emergence of new consuming behaviors that companies could monetize.

As noted, we see AI as a broadly efficiency enhancing technology, at least at this stage. To be sure, AI increasingly plays an important part in the digital transformation of various sectors, processes and products, as well as the way in which customers and businesses interact with each other. From a credit standpoint, key factors we are following are related to the extent to which firms have the financial wherewithal to invest in relevant systems and applications, as well as the underlying strategic vision and organizational commitment to doing so. It will be at least several years before the full implications for competitive dynamics within sectors become clear.

Exhibit 3

AI application uses will grow in the coming years
Intensity of integration in business processes and models

Sector		Examples of Applications
High tech		Search engines, cloud services, internet of things
Autos		Energy saving devices, predictive maintenance, autonomous vehicles
Banks and insurance		Customer analytics, software robots, targeted and personalized financial offers
Retail		Personalized shopping, optimized inventory replenishment
Media and telecoms		Personalized recommendations, automated workflows
Healthcare		Automated image diagnosis, response to medicine analysis
Utilities		Demand management and response, renewables forecasting
Consumer goods		Detection and elimination of inefficiencies, better targeted products
Commodities		Optimized logistics and distribution, improved classification of products
Transportation and logistics		Traffic tracking, delivery routes optimization
Tourism		Customer relationship management
Construction and building materials		Automatic excavation
<p>Low:  Moderate:  High: </p>		

Source: Moody's Investors Service

There will certainly, though, be many hurdles to overcome in the adoption of AI. Firstly, developing new technologies can be costly and integrating them into business processes can take time. Many industries face a number of pressing challenges, and companies with low margins and limited cash flow generation may prefer to wait for the maturation of solutions applicable to their operations. Even if management teams are willing to adopt AI technologies, they can encounter challenges in adapting the technology to their particular business context, a shortage of technical expertise and the risk of investing in an application that does not produce desired results or that quickly becomes obsolete. Firms will also need to address legal risk as AI raises questions of liability, confidentiality and privacy. Lastly, cyber risk may increase as, for example, developing smart products and processes can create more network entry points.

Finally, while the application of a given AI-based technology may raise the overall profit pool of an industry, it can also pave the way for new entrants. Some companies operating in highly competitive markets may be compelled to lower their prices, effectively passing on AI benefits to their customers. In addition, early adopters within an industry may gain a competitive advantage over competitors.

Tech firms are racing ahead

While the strides being seen in AI provide opportunities for an array of companies to develop and leverage the technology for sale to others or to augment their own businesses and product or service offerings, the largest technology companies are building commanding positions in AI. These are, essentially, the group of so-called big tech companies, including Alphabet, Microsoft, Amazon, [Apple Inc.](#) (Aa1 stable), Facebook Inc. (unrated), [International Business Machines Corp.](#) (A1 stable), [Intel Corp.](#) (A1 stable) and [NVIDIA Corp.](#) (A3 positive) in the US, and [Tencent Holdings Limited](#) (A2 positive), [Alibaba Group Holding Limited](#) (A1 stable) and [Baidu Inc.](#) (A3 negative) in China. They have already incorporated AI in their business models. For example, Alphabet and Facebook use this technology to enhance their programmatic advertising.

While other financial and nonfinancial companies like [JPMorgan Chase & Co.](#) (A3 stable), [Goldman Sachs Group Inc.](#) (A3 stable), [General Electric Co.](#) (A2 stable), or [Siemens Aktiengesellschaft](#) (A1 stable) are also investing in AI, the big tech firms dominate the landscape, as shown notably by recent M&A transactions (see Exhibit 4). Alphabet alone purchased 12 AI companies between 2012 and July 2017.

Exhibit 4

A handful of technology firms acquiring AI companies Recent acquisitions of artificial intelligence companies

M&A Date	Company	Country	Sector	Acquirer
7/12/2017	Halli Labs	India	Natural language processing (among others)	Google
7/5/2017	KITT.AI	United States	Natural language processing	Baidu
5/17/2017	Niland	France	Music search and recommendation	Spotify
5/15/2017	Lattice	United States	Unstructured data	Apple
4/13/2017	xPerception	United States	Computer vision	Baidu
3/8/2017	Kaggle	United States	Data science community	Google
2/21/2017	Wrapidity	United Kingdom	Data extraction	Meltwater Group
2/20/2017	RealFace	Israel	Facial recognition	Apple
2/16/2017	Raven Tech	China	Smart home	Baidu
2/10/2017	Argo AI	United States	Self-driving	Ford Motor Company
2/8/2017	Invincea	United States	Cyber security	Sophos
1/13/2017	Maluuba	Canada	Natural language processing	Microsoft
1/9/2017	Harvest.ai	United States	Cyber security	Amazon

Source: CB Insights

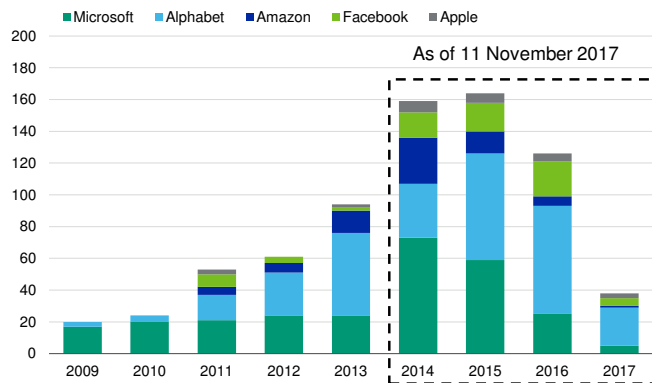
Through such acquisitions, big tech firms have not just acquired technology or clients but also skilled employees, a crucial resource at a time when the talent pool is still small. These firms are also opening research labs and partnering with universities to expand their access to talent and exposure to new algorithms.

As evidence of their growing use of AI, the big tech firms are also filing a growing number of AI patents, as shown in Exhibit 5 (note that 2014–2017 numbers likely understate the actual number of applications as there is a substantial time-lag between the filing and the publishing of the application). Between 2009 and November 2017, Google applied for nearly 300 AI-related patents, followed by Microsoft with about 270 patents (see Exhibit 6). These patent applications cover everything from computer vision (using facial recognition to authenticate users in online payments, for instance) and prediction of consumer behavior, to robotics and autonomous driving.

Exhibit 5

US tech firms are filing a growing number of AI-related patents

Patent applications of main US tech firms



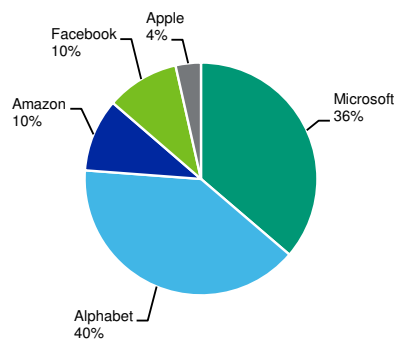
Note: The patent filing process involves a significant time-lag before the publishing of patent applications. This delay can range from several months to two years. Therefore, records prior to 2013 are likely complete but there may be applications for the 2014-2017 period that have yet to be published

Source: CB Insights

Exhibit 6

Most of the AI patent applications come from Alphabet and Microsoft

Breakdown of patent applications by the largest US tech firms between 2009 and November 2017



Source: CB Insights

A key supporting factor for the big tech firms' investments in AI technologies is their significant financial flexibility, with very strong business fundamentals and strong liquidity. For instance, Alphabet reported a Moody's-adjusted debt/EBITDA of 0.3x on a gross basis as of September 30, 2017, as well as \$11 billion of cash and \$90 billion of marketable securities. These companies are also very profitable and cash flow generative. For instance, Apple achieved a last twelve months EBITDA margin of nearly 34% as of December 30, 2017 and generated over \$39 billion of free cash flows, on a Moody's-adjusted basis.

Taken together, these factors provide the biggest technology companies with a formidable and, to some degree, self-reinforcing position in AI and related markets:

- » **Developing and selling AI solutions.** To implement AI technologies, companies will likely use solutions or platforms developed by tech firms rather than developing them in-house. This will provide the big tech companies with the potential to capture a large share of the value added that AI will create, consolidating their competitive position within their industry but also enabling them to enter new markets — as service providers or direct competitors — such as banking or automotive.
- » **Bolstering existing cloud businesses.** The big tech companies already hold a commanding share of the large and growing cloud computing market, with Amazon first among these. These businesses have been bolstered by the rise in data collection that we have noted is contributing to the recent advancement of the technology. To wit, as companies look to collect and glean actionable insights from their data, cloud systems provide a means to store, organize, manipulate and analyze these raw materials. And, it is expected that the addition of AI-based technologies will improve the quality and capabilities of their cloud services and could provide a competitive advantage over other firms engaged in selling such services.
 - For example, some of these firms also offer cloud services that include the ability to access and utilize their AI/machine learning algorithms – such as natural language processing or image recognition – to the customers' products. Further, given the scarcity of top AI development talent, Google and others have also announced new AI systems that have been trained to build new systems.
 - While not the only providers of such solutions, the combination of reputation, cloud capabilities and potential for access to a broader ecosystem offer a compelling draw for customers and the potential for a further strengthening of their competitive position.

- » **Paving the way for intelligent personal assistants.** The development of intelligent personal assistants is one of the most visible effects of AI on people's lives. With their smartphones, people can use Google assistant, Apple's Siri, Amazon's Alexa or Microsoft's Cortana to perform small tasks such as ordering a taxi or playing music. AI-powered devices like Amazon's Echo, Google Home and soon, Apple's HomePod, have entered our homes. With global smartphone sales reaching over 1 billion devices per year and home devices sales in the millions, and expected to grow exponentially over the coming years, big tech companies are able to use this technology to bring users deeper into their ecosystems by becoming the primary interface with business and even connected objects, and gathering information on users' preferences to strengthen their offerings and capabilities.
- Intelligent personal assistants will become more pervasive as their functionalities improve. In November 2014, Amazon Alexa had only about a dozen of functionalities; today, US customers can use more than 15,000 voice-activated applications. In the future, intelligent personal assistants will be able to answer increasingly complex queries and could serve as the interface for a significant share of customer interactions. In order to become part of these ecosystems, brands may have to pay tech companies an advertising-like fee or provide services at discounted prices.
 - In addition, interactions with intelligent personal assistants tend to standardize the product or service they provide since customers do not need to access the brand's website or application. This could be a risk for banks: If checking accounts or making payments with a personal assistant becomes a similar experience regardless of the customer's bank, price competition could increase as a result. In any case, we think that the growing importance of intelligent personal assistants will force many companies to rethink their business model.

AI could affect human resource allocation within firms and across countries

As AI transforms processes in the manufacturing and services sectors, several tasks previously performed by human labor could be automated. This could have varying implications for different economies and different segments of the labor force.

First, if AI technology becomes widespread across several sectors, it could boost overall productivity and growth in an economy, and create employment in high technology sectors. This would be particularly true in regions, countries and sectors that exhibit a high degree of technological innovation and agility in adapting to new competitive dynamics.

In addition, the current phase of technological innovation intersects with the ongoing aging of populations in many countries. Automation could offset the lower growth, or in some cases the decline, in labor force in these countries. To the extent that machines can undertake activity that previously required human labor, the rise of AI will compensate for the negative impact that aging would have otherwise had on growth.

However, automation could also displace human labor currently employed in a range of sectors. The net impact of automation on employment and wages will then depend on the extent to which technology, or other trends, create new types of jobs, and the extent to which the work force could be trained to undertake new and emerging jobs. For companies, ranging from manufacturers to call centers, the rise of AI could change the competitive landscape and lead to a shift in how human resources are allocated.

Moreover, as manufacturing, in particular, and services, to some extent, have become highly integrated across countries, the adoption of automation in one country now has implications both within and beyond its borders. For example, in some sectors technology may now make it more efficient to automate and bring onshore certain processes that had previously been offshored to destinations with lower labor costs. Such onshoring would have implications for the emerging markets that are heavily reliant on offshored services or global manufacturing production chains.

Case study 1: Autos - Autonomous driving will contribute to a transformation of the industry

Applications of AI in the sector

On November 7, 2017, Alphabet's subsidiary Waymo announced the testing of fully autonomous cars on public roads without anyone in the driver's seat. Many other companies are developing similar technologies: At the time of Waymo's announcement, 44 companies were given approval to test autonomous vehicles in California, compared with 11 in 2016.

Exhibit 7

Testing of autonomous cars has accelerated

Companies approved to test autonomous vehicles in California

2016: 11 companies		November 2017: 44 companies		
BMW	Altmotive	CYNGN	Nissan	Telenav
Bosch	Apple	Daimler	Nullmax	Tesla
Daimler	Aurora	Delphi	Nuro	TuSimple
Delphi	AutoX	Drive.ai	NVIDIA	UATC
Ford	Baidu	Faraday & Future	PlusAI	Udacity
GM Cruise	Bauer	Ford	Pony.AI	Valeo
Honda	BMW	GM Cruise	Renovo	Volkswagen
Nissan	Bosch	Honda	Roadstar.AI	Voyage
Tesla	CarOne	Jingchi	SAIC	Waymo
Volkswagen	Changan	Navya	Samsung	Wheego
Waymo	Continental	NIO	Subaru	Zoox

Source: California Department of Motor Vehicles

Along with electrification and connectivity, self-driving cars will have a profound effect on the automobile market over the next decade. However, we do not think that autonomous cars will substantially affect credit quality over the next two years since this new technology is still facing major technical and regulatory challenges. The public trial of Waymo's cars will take place only around Phoenix because the region has good and stable weather patterns and well-maintained roads. That said, cars allowing drivers to cede control in certain situations will spread gradually over the next five years and carmakers may start to sell fully autonomous cars around 2025.

Self-driving cars will have far-reaching effects on the industry and beyond. For instance, they will free time for drivers, who will be able to spend traveling time working, relaxing, or accessing entertainment. They will also lead to improved safety as autonomous vehicles are less likely to get into accidents. In addition, self-driving cars could change people's behaviors and lead to an increase in car sharing and the development of robo-taxis. Lastly, this new technology will modify city planning by changing traffic and parking needs.

Autonomous driving technologies will also affect sectors outside the car industry. They are already used in mining and farming when vehicles can move in a restricted environment, such as a private road. Many companies such as Uber Technologies Inc. (unrated) and [Daimler AG](#) (A2 stable) are also testing trucks with various autonomy features.

Credit considerations

Although autonomous vehicles will likely not change the credit quality of automakers by 2020, they could have substantial consequences in the longer term. While automakers today derive most of their revenues from car sales, selling data could become a large earnings source in the future if it can be retrieved cheaply. Intel estimates that an autonomous vehicle will generate four terabytes of data per day. Car manufacturers could also start selling robo-taxi services. Lastly, the increased technological content of vehicles will give automakers an opportunity to capture a larger share of the after-sale market, as customers may prefer to contact the car manufacturer instead of a third party given the safety-critical nature of autonomous driving features. On the downside, changing mobility behaviors could lead to a decline in car ownership.

While the car industry's revenue mix will change, its ecosystem will also evolve. The rise of autonomous cars will allow tech firms to enter the market, although many are now focusing on providing autonomous navigation systems instead of creating an entire autonomous vehicle from scratch. At the same time, this shift will increase cooperation among automakers, parts suppliers and

technology companies given the high development costs and technological challenges involved. The precision mapping company HERE (unrated), whose products play a major role in autonomous driving, is a good example of this trend: its shareholding structure comprises automakers such as [Volkswagen Aktiengesellschaft](#) (A3 negative), [Bayerische Motoren Werke Aktiengesellschaft](#) (A1 stable), Daimler AG, and technology companies like Intel and Pioneer Corp. (unrated).

Case study 2: Manufacturing - Large productivity gains on the horizon

Applications of AI in the sector

The industrial and manufacturing sector is an early adopter of AI technologies. Siemens estimated in 2017 that 34% of US manufacturers used advanced analytics tools and that 65% had connected sensors in plant operations. Many industrial companies have entered the so-called "fourth industrial revolution," or "industry 4.0," a digital transformation of the value chain leading to increased automation and data exchange.

In this new environment, manufacturers can use the vast amount of data they generate to make their factories more efficient or improve their products. Intel estimates that a smart factory will generate one million gigabytes of data per day by 2020. Companies can use AI to process this data and predict future demand trends or identify potential constraints in the supply chain. Many manufacturers are already using AI to produce better products. For instance, Siemens has designed turbines that can reduce emissions of toxic gas by learning from operating conditions. Likewise, AI-powered machinery enables the Korean steelmaker [POSCO](#) (Baa2 positive) to enhance the quality of its galvanized steel.

AI will also improve R&D efficiency by optimizing product development. It can help designers create prototypes, simulate real-world performance and choose parts or suppliers. Today, the startup Motivo (unrated) helps semiconductor manufacturers to solve design problems, which reduces iterations and testing costs.

Predictive maintenance is another valuable facet of AI applications. Today, industrial equipment is often serviced on a fixed schedule, irrespective of actual operating condition, potentially resulting in wasted labor and increased risk of undiagnosed equipment failures. By analyzing historical patterns and current operating conditions, AI technologies can help to identify imminent failures and notify a technician or place a replacement order. Predix, a software platform developed by General Electric, uses machine learning to detect anomalies, direct controls and predict maintenance, among other things.

Error detection is another example of AI applications. The Swiss capital goods company [ABB Ltd.](#) (A2 stable) has partnered with IBM to develop solutions enabling factory workers to spot flawed products on the production line. According to the companies, the new AI technology is faster than production line workers alone, and can detect faults invisible to the human eye. Such innovations may enable manufacturers to inspect every product coming off the line instead of random samples.

Credit considerations

AI should have a positive credit impact on manufacturing companies mostly because of productivity gains, though larger companies may have greater ability to invest relative to smaller manufacturers. We expect savings to come from a multitude of processes such as R&D, production, supply-chain management, procurement or after sale. For instance, AI can reduce inventory costs by forecasting supply and demand more accurately. New technologies will push automation further and reduce headcount in factories. Today, collaborative robots can work alongside humans and learn by imitation.

While most of the gains are likely to come from lower expenses, AI can also be a source of additional revenues, for example in the industrial software market. Software is becoming increasingly embedded in hardware and business models are evolving towards expanding data and connectivity throughout the value chain, reaching suppliers and customers in addition to the manufacturer itself. This information flow creates an ecosystem that companies can monetize. Predictive maintenance services are also credit positive because they allow the manufacturer to enter into a long-term servicing contract, which will provide stable cash flows.

Case study 3: Retail - High competition will mitigate productivity gains

Applications of AI in the sector

We believe that AI has the potential to transform the retail industry in many ways. Retailers have large datasets of transactions and customer profiles that can be used to predict future purchases. Some applications available on IBM's Watson AI platform can already analyze in-store behavior to generate new shopper insights or deliver personalized offers and promotions. In the future, retailers will use

AI analytics to forecast visits and sales in a particular store in the coming days and decide which locations should be opened or what their optimal merchandise mix should include.

Retailers will also use AI to optimize inventories and logistics. For instance, the UK retailer [Wm Morrison Supermarkets plc](#) (Baa2 stable) partnered with the startup BlueYonder (unrated) to improve demand planning and replenishment based on customer behavior in every store. This has led to a reduction in inventories and better product availability. Retailers can also use AI in warehouses to increase productivity and reduce injuries. [Ocado Group plc](#) (Ba3 stable), a UK online retailer, automatically reorders stock from suppliers and uses machine learning-powered robots to retrieve from storage the groceries to fill customer orders.

Retailers will also be able to build on AI technologies to enhance shopping experiences through, for example, individually tailored product recommendations based on a shopper's style. For instance, the e-commerce company Alibaba uses data collected from transactions made across its platforms to personalize search results and advertisements. [Liberty Interactive LLC](#) (Ba3 stable), the owner of home shopping network QVC, can collect and analyze data to respond to consumer trends in real-time. Many retailers including [Macy's Inc.](#) (Baa3 stable) have also developed chatbots to support customer interactions. Such virtual assistants can also provide shopping recommendations.

Credit considerations

AI has the potential to bolster retailers' credit quality by increasing cash flows. Companies successfully implementing new technologies will boost their revenues by improving in-store and online conversion rates, proposing products tailored to their customers' needs and optimizing prices. AI will also help lower costs by reducing manual activities in areas such as promotions, assortment and supply chain. Smart chatbots could yield substantial savings by automatically managing thousands of conversations at the same time. And, AI can reduce working capital by cutting inventories. Lastly, we think that AI will enable retailers to reduce capital spending by optimizing their physical footprints.

Still, we think that the benefits coming from AI will be uneven. The retail industry is highly competitive so the positive effects of AI will depend on the retailers' ability to keep higher margins instead of lowering their prices. In addition, large companies have a head start compared with smaller retailers thanks to their larger budgets and datasets, although the emergence of external providers of AI technologies could level the playing field.

Case Study 4: Financial services - Key part of the digital transformation

Applications of AI in the sector

Given their long history of collecting, maintaining and analyzing large data sets, banking, insurance and asset management firms are particularly well-positioned to apply and benefit from various components of AI technology in a range of core processes and products, and position the financial services sector as particularly intensive users of the technologies today.

The most common of the current applications fall into four main buckets – leveraging data to improve underwriting decision making (e.g. credit and insurance products), portfolio management (e.g. robo-advisors), customer interactions (e.g. chatbots) and operational processes.

Underwriting – Better and faster decision making and pricing

Banks and insurance companies have long relied on data for making underwriting decisions. The realities of limited technological capabilities and marginal cost of human interactions have meant that the range of inputs has been relatively limited. However, the advent of machine learning and data analytics provided by underlying AI technologies, along with the increasing amount of data available on individual retail and commercial customers, allows banks and insurance companies to gain additional insights on defaults or anticipated claim costs. This provides opportunities for lower-cost decisions and more informed risk analysis for product pricing as well as faster and, potentially greater, access to products and services for customers.

Investment advisory

The term robo-advisor moved into mainstream parlance some years ago. These are digital platforms that provide automated, algorithm-driven financial planning with little human supervision. They recommend portfolio composition based on a set of information provided by the clients, and generally focus on stock and bond exchange-traded funds as investment vehicles. They are also capable of handling more sophisticated tasks such as tax-loss harvesting, investment selection and retirement planning. While

relatively new, robo-advisors have upwards of \$200 billion in assets under management now, which is expected to grow exponentially over the coming years as the millennial cohort – typified as being more comfortable with digital interactions and demanding of the choice, convenience and personalization emerging technologies promise – amasses more investible wealth and the “mass affluent” are drawn by the cost advantages.

Customer Interactions – Chatbots

While better targeting and pricing products is, perhaps, the most important facet of customer interactions, chatbots, built on natural language processing and machine learning, provide a customer service solution for processing common transactions and enquires. This solution is cost effective for the company, reducing the need for human intervention, and convenient for customers as chatbots are always available and can respond many times faster than human representatives.

In addition, advancements in machine learning, natural language processing and facial recognition are expected to provide the opportunity to augment other financial services interactions. For example, in asset management, facial recognition software is being developed that measures the client's expressions and responses to watching a series of videos, analyzing responses to scenarios and the advisor (or bot) to match the client with a portfolio, product, or service that best meets their needs.

Back- and middle-office processes

Efficiency is essential in the back- and middle-office to ensure daily operations run smoothly. In particular, machine learning can help improve various tasks in risk management, regulatory reporting and financial operations. As regulatory capital has increased tremendously post 2007, financial institutions are faced with the task of complying with regulatory rules while constructing an optimized balance sheet that's used to its capacity. Machine learning is able to add onto the traditional forms of optimization techniques to increase speed and accuracy. To reduce cost and improve timely delivery, natural language processing is able to automate many parts of regulatory reporting. And finally, learning through mass amounts of data, machines are able to improve operational efficiency by identifying and reducing errors more quickly and accurately than human staff.

Credit considerations

When considering the application and potential risk factors associated with AI and financial services, it is important to note the sector is in the midst of a broad “digital transformation.” This shift is being driven by a number of factors, including the emergence and increasing maturity of various enabling technologies, growing importance of digital distribution channels and the rise of new entrants focused on applying these technologies to one or more businesses or product segments. In turn, this is driving customer demand for more bespoke products and services and seamless interactions with financial services firms.

In this context, AI ranks high among the new technologies that are both enabling incumbents to derive efficiency gains and opening the door to new entrants to gain market share. Indeed, while increased digitization, in general, can allow smaller entrants to scale quickly and cost effectively, this can be amplified by the increasing use of machines to undertake a range of tasks – from the routine to the more complex – reducing some of the capital investment and operating cost hurdles they might otherwise face.

- » In banking, for example, the introduction of “open banking,” which provides third parties access to a customer's underlying account data and use histories, will also fuel AI-driven enhancements to the tailoring and delivery of products and services.

Appendix - Overview of AI technologies and applications

This publication focuses only on “narrow” AI technologies, which perform a single task such as image classification or spam filtering. In contrast, “broad” AI refers to systems able to exhibit intelligent behavior across a variety of tasks, which remains today a theoretical concept.

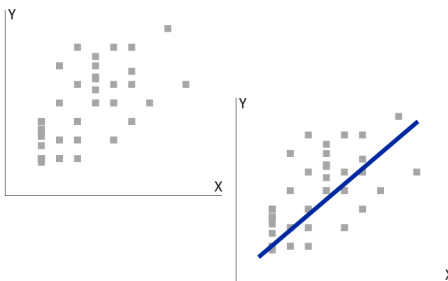
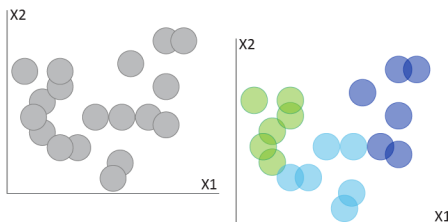
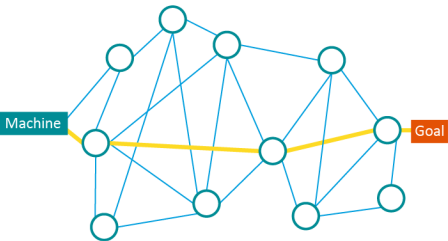
Many AI technologies are based on machine learning, a field of computer science that gives computers the ability to learn without being explicitly programmed. The machine examines a data set, extracts meaningful patterns and becomes able to make a prediction. For instance, machine learning can allow a computer to predict house selling prices by analyzing a database of real estate transactions.

Machine learning can be broken down into three categories: supervised learning, unsupervised learning and reinforcement learning. These three categories are used to solve different types of problems, and sometimes they are used together to tackle more complicated problems, which Exhibit 8 illustrates.

Exhibit 8

Machine learning can perform different tasks

Overview of some machine learning techniques

SUPERVISED LEARNING		
<ul style="list-style-type: none"> » Machine is given a set of training data - a collection of inputs X, each with an output, Y » Observes the data and tries to predict Y for each input X » Compares its prediction with the actual Y » Improves accuracy of prediction by learning through a large amount of training examples » Two major questions are 'regression' and 'classification' 	Application <ul style="list-style-type: none"> » Stock price forecasting: X = historical price, Y = future price » Image recognition: X = image of the object, Y = name of object 	
UNSUPERVISED LEARNING		
<ul style="list-style-type: none"> » Machine is given a set of training data – a collection of X's but no Y's » Learns the structures and relationships among the X's » Produces meaningful results based on knowledge learnt » Often used for clustering analysis 	Application <ul style="list-style-type: none"> » Market segmentation: X = characteristics and preferences of a group of consumers Result = partition the group of consumers into different market segments 	
REINFORCEMENT LEARNING		
<ul style="list-style-type: none"> » Machine is given an environment, a list of possible actions, and a specific goal » By performing an action, it changes the environment from one state to another » The system is rewarded for an action that gets closer to the goal and penalized for the contrary » Through training, the machine learns the consequences of actions and finds the best actions to reach the goal 	Application <ul style="list-style-type: none"> » Inventory optimization: Goal is to replenish inventory at the right time. The machine is penalized for storage shortages or excesses. Through training, it learns the best way adjust inventory 	

Source: Moody's Investors Service

The scientist Arthur Lee Samuel coined the term "machine learning" in 1959 but innovations have been slow until recently. In 2012, the computer scientist Andrew Ng used recent advances in computer hardware to implement for Google a large neural network, a type of machine learning algorithm mimicking the human brain, to analyze YouTube videos. From that point, artificial intelligence technologies developed very rapidly across many sectors. Its main uses include computer vision, natural language processing or information retrieval, which the following exhibit illustrates.

Exhibit 9

AI today covers a broad range of technologies and applications**Main uses of AI technologies**

Source: Moody's Investors Service

Moody's related publications

Outlook:

- » [Cross-Sector — Global: 2018 Outlook: Credit conditions improve as healthy economic growth moderates financial stability and political risks, November 2017](#)
- » [Diversified Technology - Global: Stable outlook on expectations for modest revenue growth and profit gains, October 2017](#)
- » [P&C Commercial Insurance - US: Stable Outlook - Well capitalized sector faces weak pricing, declining profit margins, September 2017](#)

Sector in-depth:

- » [Automotive - Europe: Auto sector faces higher capital spending, residual value risk, but well-positioned to cope, January 2018](#)
- » [Automotive Industry - Global: Automakers fully engaged on Battery Electric Vehicles, but the transition will pressure returns, January 2018](#)
- » [Asset Management – Global: The second wave of disruption will be digital, November 2017](#)
- » [Insurance: Sector Generates Underwriting Profit, Margin Compression Ahead, July 2017](#)
- » [Sovereigns – Global: Robotics' Impact on Emerging Market High-Tech Exporters Depends on their Technology Absorption Capacity, May 2017](#)
- » [Non-Financial Corporates - North America: M&A Rolls On, Raising Near-Term Leverage and Risk in Exchange for Benefits Over Time, February 2017](#)

Sector comment:

- » [US Semiconductors: Lam Research's Strong Results and Outlook Bode Well for Applied Materials, November 2017](#)
- » [Health Insurers - US: Big Data Is Helping Drive Down the Cost of Managed Care, April 2017](#)
- » [Insurance – Global: With Big Data Come Big Advantages, June 2016](#)
- » [Cross-Sector - Europe: Autonomous Vehicles Will Drive Change from Auto Manufacturing to Insurance, May 2016](#)
- » [P&C Insurance - Global: Self-Driving Cars Could Send Auto Insurers Skidding, March 2016](#)

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