ARCANO

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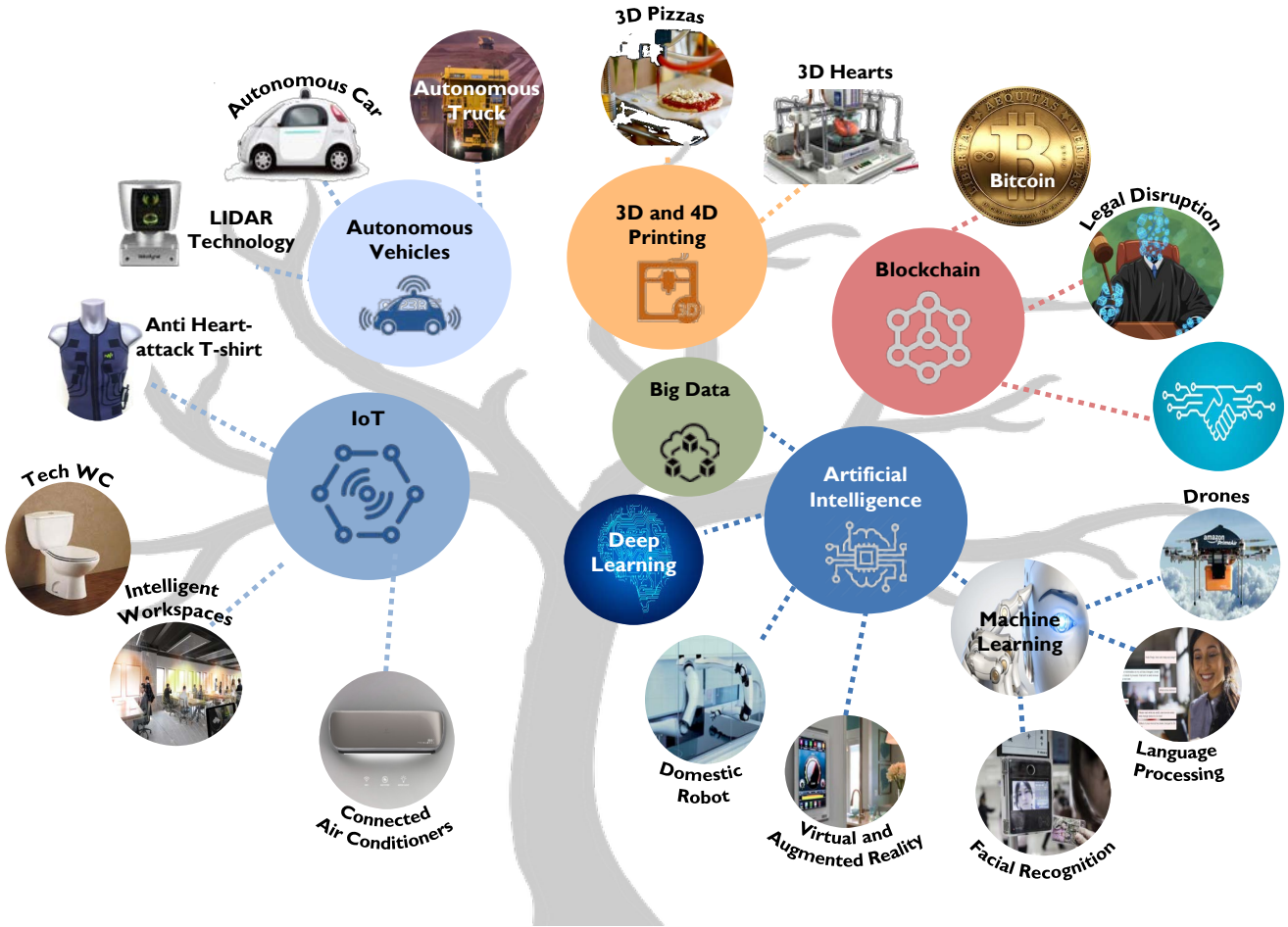
Technological Disruption Is Already Here

How it affects people, governments and businesses



Report summary video

Ignacio de la Torre, Ph. D.

idelatorre@arcanopartners.com

+34 91 353 21 40

Leopoldo Torralba

ltorralba@arcanopartners.com

+34 91 353 21 40

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www.arcanopartners.com

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About 'Technological disruption is already here: how it affects people, governments and businesses'

- We are in the dawning years of a new technological revolution, with innovative technology growing at an alarming rate. This advancement, which always seems to threaten leaving us all behind, instigating fundamental social and economic changes, evokes strong feelings of anxiety and fear of the unknown. This report seeks to address the underlying causes instigating this arousing of emotion with the hope of comforting through educating; approaching, in the most straightforward way possible, the different technologies, their rate of adoption and their foreseeable economic, sectoral and social impact.

About Urizen, Arcano's Venture Capital Fund

- Urizen is a US-orientated venture capital fund investing in Artificial Intelligence (AI) applied to the real economy. Led by Adeyemi Ajao and TJ Nahigian, the Urizen Ventures team is one of the most renowned in Silicon Valley for their unique profile which combines investment and entrepreneurial experience. So far, they have successfully invested more than 350 million dollars in 60 companies.
- The fund will follow the strategy developed by the team in recent years and will continue co-investing jointly with the best American venture capital funds, such as Sequoia Capital, Accel Partners, IVP, Lightspeed Venture Partners and Andreessen Horowitz, among others. This is a totally distinguishing feature since 20 of the best funds of this type represent 95% of the sector's capital gains, with the entry of new investors being completely restricted.
- Urizen invests in technological companies such as ETHOS, which uses AI to accelerate real estate-related procedures or Marven, an AI-powered software to assist direct sales in the industrial sector.

About the authors[1]

- **Ignacio de la Torre** has been a partner of Arcano since 2008. He has 20 years' experience in capital markets, having worked for Arcano, UBS and Deustche Bank. He authored the series of reports titled 'The Case for Spain', which first anticipated the change in the Spanish economic cycle back in 2012. He holds a MBA from INSEAD, a BA in Economics from ICADE, as well as a BA in Law and a PhD in History from UNED. Ignacio has been lecturing economy in the IE Business School since 2003. He is the author of four books and winner of the Everis prize in 2009, jointly with Leopoldo Torralba.
- **Leopoldo Torralba** joined Arcano in 2015. He is Ignacio de la Torre's macroeconomic and market research analyst. Previously, he worked as an equity research analyst at Ahorro Corporación Financiera, and as member of the Strategic Planning and Management Control division of Grupo Ahorro Corporación. Since 2008, he is associate professor of finance (banking finance) at IE Business School. He holds a Master's Degree as Professional European Financial Analyst from IEAF, an MBA from IE Business School, and a BA in Economy from the University of Zaragoza. He is the joint author of a book, with Ignacio de la Torre, for which they won the Everis prize in 2009.

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Executive summary

By the end of 2017, seven out of the eight largest companies in the world were in the tech business – barely ten years ago, there was only one amongst the top twenty-five. Four out of the seven wealthiest individuals are founders of technological companies. The value of one internet-based advertising company alone, such as Google or Facebook, is twenty times that of the US' most important broadcasting network, CBS. The market capitalisation of the e-commerce giant Amazon doubles that of WalMart, and is 500-fold that of Sears, another big retailer. New disruptive technological companies are being set up every day; some of them reach valuations of more than one billion dollars at record-breaking speed, without even being listed; these are known as 'unicorns'. At present, there are already 215 of these unicorns whose aggregated value amounts to 747 billion dollars. Uber, the transportation Company, is one of these unicorns; it has been recently valued at more than 60 billion dollars, which exceeds the valuation of all the car rental companies together. The valuation of the flat sharing company Airbnb, eight years in, is above that of the hotels giant Marriot, with 80 years of history. Recently, SoftBank launched 'Vision', a venture capital fund for those wanting to invest in the technological revolution, and with 93 billion dollars, it is probably the largest private capital fund ever launched.

In 1960, General Motors was the most valuable company in the world with 600,000 employees and earnings of 7.6 billion dollars in current money. Nowadays, Apple occupies the top spot in the rankings, with earnings of 84 billion dollars, more than ten times those of General Motors, but only 116,000 employees.[2] In other words, Apple's net profit per employee is 57 times that of General Motors at that time, thus raising the question of whether in the future there will be jobs for everyone. Quoting Voltaire, "Work keeps at bay three great evils: boredom, vice and need", and I would include self-dissatisfaction to this list. If we are concerned about the future of jobs, we should keep a close eye on these four inherent evils.

What is happening? The combination of increasing capacity to process data and the use of advanced algorithms to treat and analyse that data is accelerating technological disruption. The Apollo Guidance Computer which made possible the great feat that was the moon landing had approximately 12,300 transistors; the iPhone 7 has over 3.3 billion. The internet has gained incredibly in popularity – it is already accessible by almost half of the world's population and its price has been sharply reduced. Smartphones have also become affordable to most people; entry-level smartphones can cost under 30 dollars and are available all over the world, permitting anyone access to more information than what the US President had in 1990. Moreover, modern sensors can connect virtually any machine to the internet, accumulating huge amounts of data. All this constitutes the breeding ground for technological disruption, a process which is being called 'the fourth industrial revolution'. The innovations of this revolution are taking place at an unprecedented rate, with change occurring ever more rapidly.

The revolution is illustrated, in part, by the five main technologies that we analyse in this report: artificial intelligence (hereinafter, AI) and its robotic implications, the Internet of Things (hereinafter, IoT), autonomous vehicles, Blockchain and 3D and 4D printing. These technologies will disrupt the future of key sectors of the economy and are behind the venture capital revolution, unicorns and giant listed tech companies.

Moreover, disruption will bring about significant consequences such as the loss of jobs and the creation of new ones, providing modern education with the central role of ensuring a smooth and positive evolution into this new technological age. This report also deals with these processes and the foreseeable future. Despite our optimism in the capacity of humans to adapt to change and create new jobs in the medium term (one must only look back at the past to see human capabilities), in the transition period, job loss will outweigh job creation, especially among the less qualified workers and in the poorest countries. This process will highlight some relevant social questions that must be addressed early so as to ensure minimum disruption and negative effects. Great opportunities will also arise as jobs will be more fun, better paid and with reduced working hours. Furthermore, technology will contribute to noticeable health improvements and enable us to live longer.

> "We are being afflicted with a new disease, which some readers may not yet have heard the name, but of which they will hear a great deal in the years to come – namely *technological unemployment.* This means unemployment due to our discovery of means of economising the use of labour outrunning the pace at which we can find new uses for that labour... The prevailing world depression, the enormous anomaly of unemployment in a world full of wants, the disastrous mistakes we have made, blind us to what is going on under the surface to the true interpretation of the trend of things."

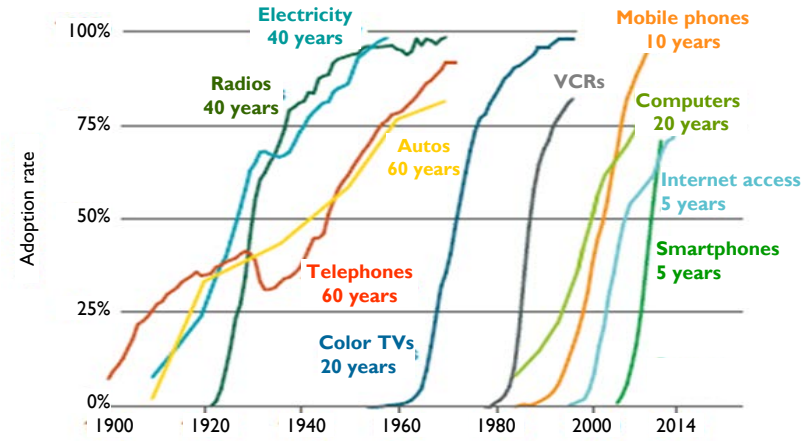
This quote is not contemporary; Keynes stated this in 1930, but we are entering into a new phase of this 'disease', facing the huge challenge that we try to analyse in this report.

[2] This statistic set out by John Lanchester in the 'London Review of Books' does not take into account that Apple outsources a large share of its production process. It is calculated that Apple has some 1.5 million outsourced jobs, thus altering the abovementioned figure.

Introduction

We all have the perception that technology is moving at warp speed and that, usually, we are unable to learn and grasp its pace or impact. Figure 1 shows precisely how the adoption rate of disruptive technologies has sped up exponentially over the last century.

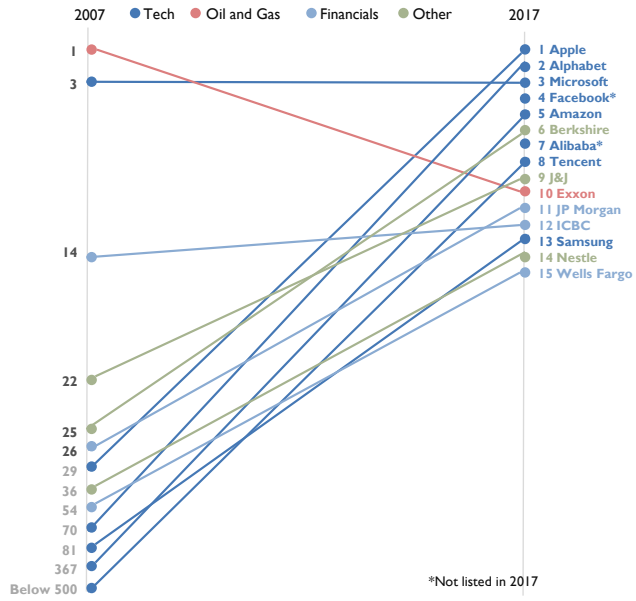
Figure 1. Adoption rate of new technologies in the US



Source: BlackRock (2014). 'Interpreting Innovation. Impact on Productivity, Inflation and Investing'

The unrelenting technological advance is clearly illustrated by the fact that seven out of the eight largest listed companies (Figure 2), and four out of the six wealthiest individuals (Figure 3) in the world, are in the tech business. Therefore, we believe that any relevant economic players, in particular entrepreneurs and investors, who want to grasp the most significant implications of the ongoing technological shift, should read this report.

Figure 2. Ranking of the world's 15 largest companies,Figure 3. The world's seven wealthiest individuals by market capitalisation



Source: Bloomberg

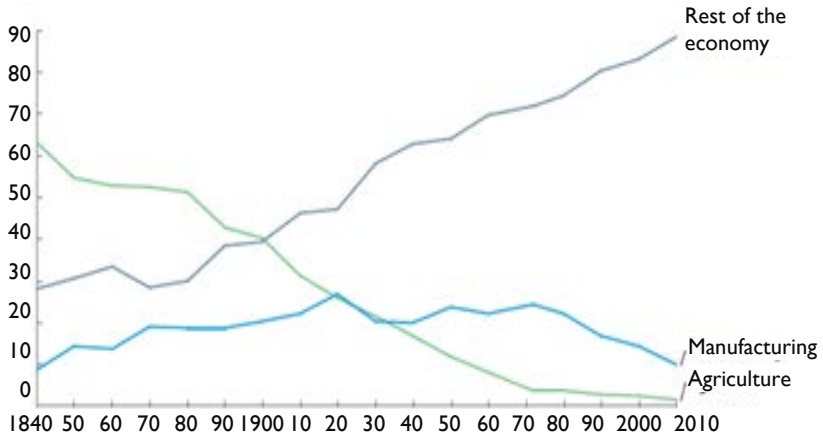
#	Name	Net worth wealth (Billion dollars)	Age	Company	Country
#1	**Bill Gates**	**$86**	**61**	**Microsoft**	**US**
#2	Warren Buffett	$76	87	Berkshire Hathaway	US
#3	**Jeff Bezos**	**$73**	**53**	**Amazon.com**	**US**
#4	Amancio Ortega	$71	81	Zara	Spain
#5	**Mark Zuckerberg**	**$56**	**33**	**Facebook**	**US**
#6	Carlos Slim Helu	$55	77	Telecom	Mexico
#7	**Larry Ellison**	**$52**	**73**	**Oracle**	**US**

Source: Forbes

The profound social and economic changes ushered in by innovation (Uber and the taxi sector are a representative example) conjure up a variety of emotions,[3] the prevailing one being fear. Our fear is evoked through ignorance, and the anxiety of an uncertain future, unknowing of what the technological disruption may bring, and unable to comprehend the true extent of said disruption. A few months ago, I held a meeting with the Prime Minister of some European country, who told me: 'my son will be 18 soon; he has asked me what type of degree he should study, and I must admit I am unable to give him any advice in view of the job disruption technology may cause in future.'

The aim of this report is to address the reasons that lie behind those emotions. By approaching the different technologies in a straightforward and understandable manner, examining their rate of adoption and foreseeable economic, sectoral and social impact, we intend to help mitigate, in part, the anxiety of the unknown, which usually instigates fear. Knowledge allows for judgement and provides the ability to approach these topics more assuredly. Thus, we may be able to make true the well-known ambivalence of the Chinese ideogram for 'crisis' with its two opposed meanings of 'crisis' and 'opportunity'. In 1900, some 40% of American workers were employed in agriculture; at present, that figure has dropped to 2%, similarly, in 1950, 25% of American population worked in the industrial sector; nowadays, they are just a mere 10% (Figure 4). However, unemployment in the US is at all-time lows (c. 4%), with the activity having moved to other sectors. Human beings are not only able to innovate, but also to adapt to changes and identify them as opportunities.

Figure 4. Distribution of labour share by sector in the US



Source: McKinsey (2017). 'A Future that Works: Automation, Employment and Productivity'

Historical background

We believe that the best possible start to our report and approach of the abovementioned underlying emotions is addressing the subject from a historical perspective. Our present concerns are not new; human beings have been troubled by the same issues for centuries. By having a look at how they have been able to successfully overcome them, we will relieve in part the anxiety that technological uncertainty generates.

In his 18th book of the Iliad, Homer (8th Century BC) tells us how the goddess Thetis meets Hephaestus "sweating with toil" as he makes a golden wheeled cart able to autonomously roll in and out the god's hall without human or animal traction. A good visionary precedent of the self-driving vehicle, dated over 3,000 years ago. The Greek philosopher Aristotle already somewhat anticipated AI in his '*The Politics*' (350 BC) when he proposed analysing a set of rules about how the human mind works in order to automatically extract rational conclusions, something that according to the Greek scholar could lead to the automation of tasks, allowing for the replacement of slavery: "for suppose that every tool we had could perform its task either at our bidding or itself perceiving the need, then master craftsmen would have no need of servants, nor masters of slaves". This idea was later applied, to some extent, by Ctesibios of Alexandria (250 BC), who invented a device to regulate water flow (rational but with no reasoning).

In 1315, the Majorcan scholar, Ramon Llull, exposed, in his *Ars Magna,* the idea that reasoning could be artificially created, and so he endeavoured to devise a 'logical machine'. In the 16th Century, the Italian inventor Leonardo Da Vinci

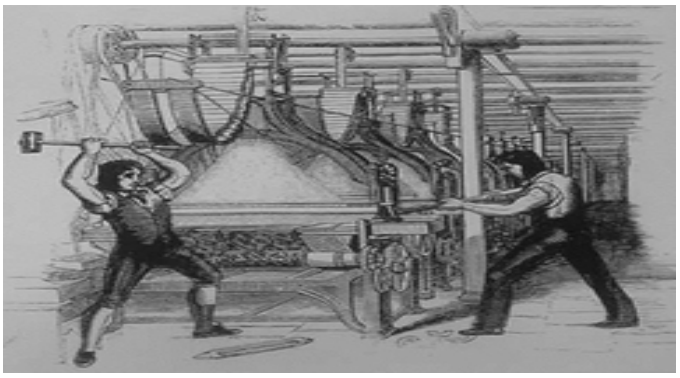
[3] From the Greek word meaning 'movement'.

attempted to design a three-wheeled self-propelled vehicle, as well as outlining designs for the first robot.[4] The French mathematician and philosopher Pascal tried to apply Aristotle and Llull's intuitions to set the basis of the first calculation machine, the Pascaline (17th Century, Figure 5), which was built using concepts already developed in the Middle Ages, when we find the first examples of calculators: the Exequer or calculating tables.

The reaction to the industrial revolution, beginning in Great Britain in the 18th Century, came swiftly. This revolution caused social disruption, displacing many factory workers; fomenting anger to and fear of this new technology. The Luddites were British workers who supported factory attacks to avoid 'the loss of jobs' (Figure 6), these acts of aggression towards machinery led to the introduction of an act in 1812 declaring that the breaking of machines was a crime punishable by death.

Figure 5. Pascaline (17th Century)

Figure 6. Luddites attacking factories (19th Century)



Source: Google

On the 10th of June 1930, Keynes gave a conference at the *Residencia de Estudiantes* (Student Residence) in Madrid ('Economic possibilities for our Grandchildren') in which he exposed the risks that the use of robots could mean for jobs if they replaced workers at such a fast pace that a country's economy could not create new posts for those displaced. He coined the expression 'technological unemployment' to refer to this situation. Keynes also forecast a vast reduction in the working week; to only 15 hours by 2030, and although this has not quite come to fruition, we are undoubtedly heading in that direction (Figure 7). One year later, in 1931, Einstein would also echo this claim, as well as discussing the future impact of robots in our lives, commenting how the 'technologies that were meant to serve the world's progress by liberating mankind from the slavery of labour [were] now about to overwhelm its creators'.

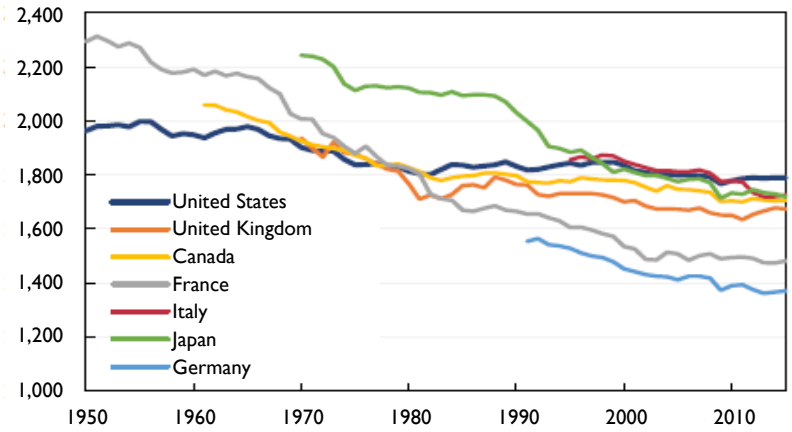
This line of thought continued, and, in the '60s, President Kennedy was already expressing his fear of the upcoming challenge of maintaining full employment with the incoming stream of robotisation. It took over twenty five years for man to get to the moon after the invention of the jet engine; however, technological development rates are ever-increasing. The Apollo Guidance Computer which made possible the great feat that was the moon landing had approximately 12,300 transistors; the iPhone 7 has over 3.3 billion allowing for an awesome amount of computation; over 2 billion app downloads a year.[5] The exponential evolution of processing power will have profound consequences, following Moore's Law of doubling. If one recalls the legend of the origin of chess, in which an Indian King, who was so pleased with the game offered the inventor any prize he desired; the man asked for a grain of rice for the first square of the board, two for the second, four for the third and so on (doubling the number of grains for each subsequent square). The King laughs it off as a meagre prize for such a brilliant invention, only to find out that the number would amount to vastly more than the kingdom, or for that matter, the world, could supply.

In any case, apart from historical episodes of temporary disruption and resistance, in the long run, technological advances have always contributed to a noticeable increase in the living standards of populations as a whole, regardless of social status or employment, with society amply adapting and new professions arising. The following Figure, 7, shows how the average number of hours worked over the last seventy years has significantly decreased.

[4] In a recent conference at Chatham House, Professor Richard Susskind lectured on the historical background of technological disruption and its impact, with references to The Iliad, Da Vinci, the Luddites, Keynes and Kennedy.

[5] Included in those apps is one blessed by the Catholic church, 'Confession', which helps Catholics to prepare themselves for confession through a simulated conversation with a priest – a sign of how times have evolved.

Figure 7. Average annual hours of work per employee



Source: Executive Office of the President of the United States (2016). 'Artificial Intelligence, Automation, and the Economy'

Today, almost half of the 7.5 billion living on planet Earth (some 3.5 billion) have access to the Internet, for most (around 3 billion) it is via a smartphone.[6] This proves the impressive global disruptive potential of technology today compared to the past. Nowadays, a humble individual in, Pakistan, for example, by spending some thirty dollars, has access to more information than the President of the United States had in 1990. This has profound implications.

Implications for the investment world

This report should be of particular interest to investors since the technological disruption will have a large impact in their professional interests' field. The best way of getting direct exposure to this revolution would be through specialised venture capital funds, whose underlying strategies are similar to those described in this report, and who have qualified, specialised management teams – some listed funds will also be able to provide this. However, as per usual when regarding venture capital funds, it is important to note that the quality standards and specialisation vary significantly from one fund manager to another, so making an adequate choice is vital in optimising the expected risk-return ratio. Moreover, from the macroeconomic perspective, a potential technology-driven acceleration in productivity growth will boost real GDP growth rates (net of inflation) significantly, with a considerable impact that is not dismissed by the market consensus. It is important to note that the technological revolution will have an uneven impact across regions, with some countries more affected than others. Investors should consider that, for example, emerging countries may see their principal competitive advantage of cheap labour costs noticeably trimmed, due to the combined effects of increasing salary growth and the continued developments in robotics.

About the report

In this report we primarily focus on three technologies that we see to be the potential principal disruptors of everyday life: AI, the IoT and autonomous vehicles, whilst also discussing, in lesser detail, two other disruptive technological breakthroughs; the Blockchain and 3D printing. We analyse the sectoral, economic and social impacts of these technologies, addressing a series of implications they may have for the investment world and finishing off with our final conclusions and recommendations. At the end we have included a glossary with a brief explanation of our most frequently used terms.

Our field of expertise is the economy, not technology, so we hope that our readers excuse our lack of depth and naivety. Furthermore, since we do not belong to the tech industry, we have tried to explain concepts which we think are complex, in the simplest possible way, so most readers are able to understand them. We are not judging whether these changes will be positive or negative. We simply expose and examine them, with the aim of providing constructive suggestions. At the end of the document we have included a brief glossary with some of the main terms used in the report.

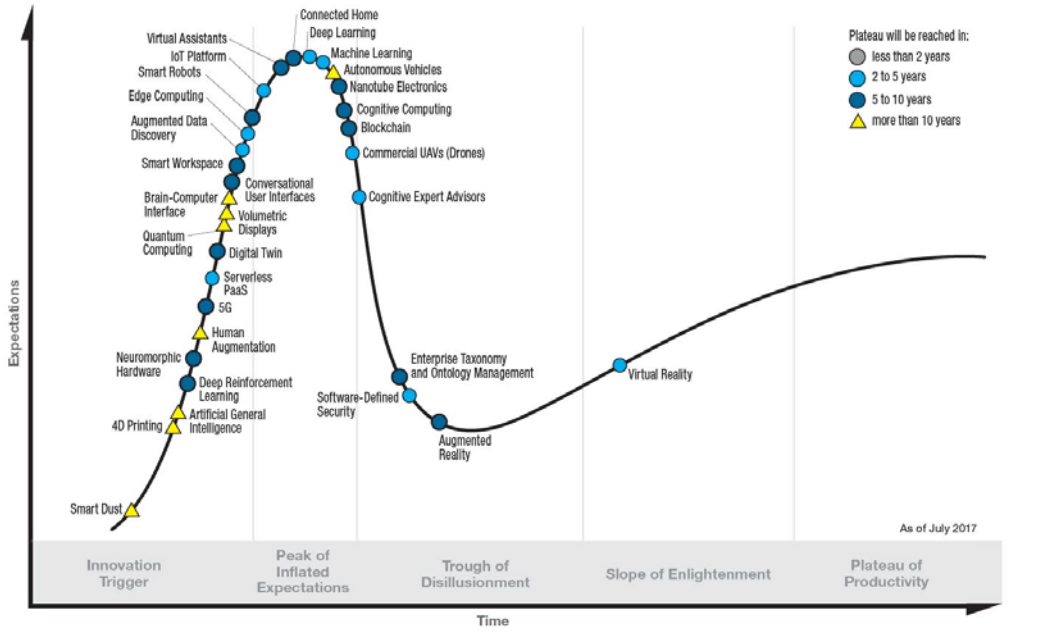
According to some estimates, by the time that current primary school children join the employed world around two thirds of their professions will be new; created in the last decade. This simple statistic should caution us, as parents, politicians or business men, about the enormous role we must play in enabling a smooth transition through education and adaption. We hope that after reading this document the abovementioned head of state, as well as some of our readers, may have a clearer idea of what to recommend to their children, preparing them for a bright future.

[6] The number will continue to grow rapidly, with dropping costs and increasing efforts to provide internet to all parts of the world, with projects using drones or balloons in the works by the types of Google and Facebook (project Loon).

1. Description of disruptive technologies

In this section, we will analyse in detail the three technologies we consider essential: artificial and related intelligences (AI), the IoT and self-driving vehicles. We will also discuss a couple more technologies that are important to us: Blockchain and 3D printing. The Gartner Cycle (Figure 8), provides a clear graphic illustration of where we are in terms of development of new technology, assessing the maturing and adoption. As is evident, most of these technological breakthroughs are still in their very early stages (innovation trigger and peak of inflated expectations). Of the technologies that we address in the report the IoT and machine learning (a part of AI) are expected to reach the productivity plateau within 2-5 years, Blockchain in 5-10 years and 4D printing and autonomous vehicles in more than 10 years.

Figure 8. Gartner Hype Cycle



Source: Gartner

1.1. Artificial intelligence, robotics and big data

Definition and concepts

Two years ago, the French retailer Carrefour introduced the robot Pepper, with support from numerous top brands, as a shop assistant in its supermarkets (Figure 9), providing information and greeting customers; an early illustration of how AI-based robotics[7] may bring a revolution to future jobs. Another popular robot is 'Baxter', built by Rethink Robotics, which costs around 25,000 dollars and is used for simple industrial jobs such as loading, unloading, sorting and handling of materials.

[7] Link to video showing the world's smartest automated robots developed by Honda and Boston Robotics: https://www.youtube.com/watch?v=rVlhMGQgDkY&t=5s

Figure 9. Softbank's Pepper robot at a Carrefour hypermarket

Source: Google

In reality, the robotics revolution started a long time ago. Nowadays, when we fill our petrol tank, we do not realise that we are interacting with a robot. The first self-service petrol stations appeared in 1964 and fuelled a huge workforce displacement, with many attendants moving on to working for the station convenience stores or elsewhere.

Artificial Intelligence (AI) consists of the application of computer systems in machines enabling them to replicate tasks or responses considered to be limited to humans. Examples of AI include IBM's Deep Blue computer, which beat the world chess champion Gary Kasparov in 1996,[8] as well as their more updated Watson AI, and Google's DeepMind,[9] whose AlphaGo application beat the world's best Go player in 2016 – the Chinese board game Go is considered to be the most tactical and complex game in the world, with more move possibilities than there are atoms in the universe. Both of these examples show AI's potential, but this technology is also present whenever we make an online purchase; Amazon's AI-based product offering takes into account previous purchases and internet search history.[10] AI is also behind the developing concept of automated supermarkets.

The term 'robot' was coined in the 1920s by the Czech author Kapec, deriving it from the Czech word for 'slave',[11] whilst the expression 'Artificial intelligence' was created by John McCarthy in 1956, who defined it as the activity devoted to making machines intelligent. AI and robotics are growingly interlinked, with AI a necessity in the solving of tasks which are not purely a repetitive action, as well as more abstract problem solving and decision making through the algorithmic processing of big data. Despite these advances, many of the predictions made over the last fifty years of the progression of robotics have no yet come to fruition, so lies ahead is relatively uncertain.[12]

[8] Actually, this feat was expected to be achieved in 1968, but it was not until thirty years later that it was realised. Kasparov's response to the loss was brilliant: 'at least my opponent has not enjoyed the victory'. Shortly later, another chess master, when asked how he would prepare for a match against Deep Blue, replied 'I would bring a hammer'.

[9] Google DeepMind is a British AI company set up in 2010 as DeepMind Technologies, and was acquired by Google in 2014. Nowadays it is devoted to the detection of eye diseases. Link to video featuring what is considered to be the greatest achievement of AI: Google DeepMind's (AI division) Alpha Go victory over the three-time world champion: https://www.youtube.com/watch?v=JNrXgpSEEIE

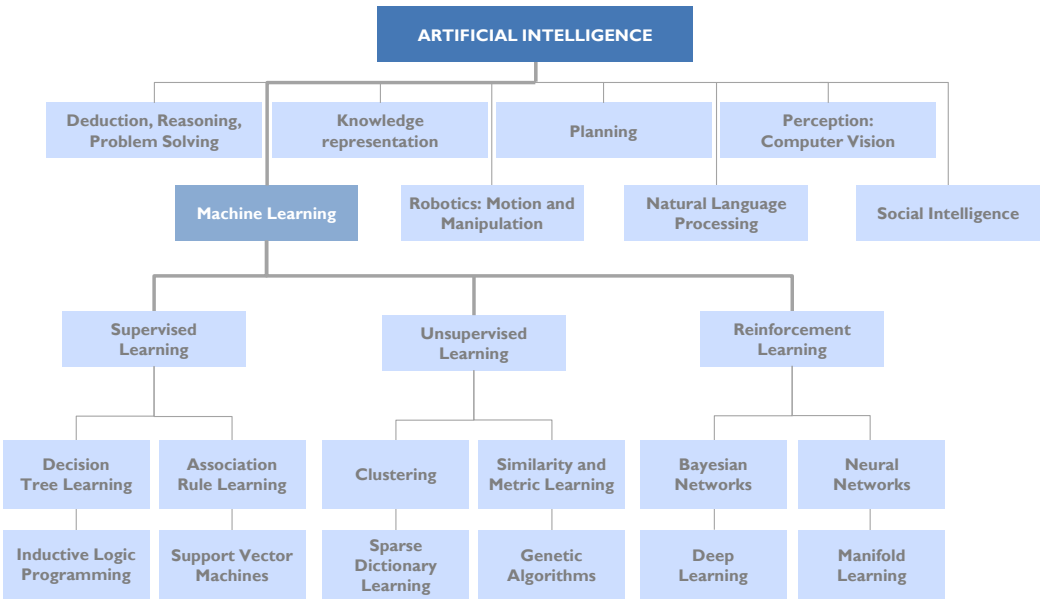
[10] Link to video featuring Amazon's supermarket, the most technologically advanced in the world: https://www.youtube.com/watch?v=NrmMk1Myrxc

[11] In Spanish and English, the word for *slave* derives from Latin *sclava* meaning Slavic 'Slavic', because of the huge flow of Slavic slaves towards Islamic markets in the past. Being a Slavic himself, Kapec understandably wanted to use a different word.

[12] The difficulty of estimating the scale of the technological disruption is illustrated by what happened to AT&T in 1985. The company commissioned one of the most prestigious auditors then to assess the future of mobile telephony in the US in the next 15 years (that is, by 2000). The consulting firm forecast that the number of users would go up to 900,000. The actual figure was 109 million. In a similar fashion, not so long ago, Nokia disregarded the potential of smartphones since it considered that not many people would be willing to pay more than 300 dollars for a sophisticated phone. Nowadays, almost 40% of the population has one.

It is important to note the division in the area between 'general AI', which looks to wholly replicate human intelligence and response, which we are still some way off of optimising, and 'narrow AI', which focuses on the optimisation of a simple, specific daily task for a machine. Artificial Superintelligence refers to the time when computers will surpass human intelligence through reasoning and complex problem solving. DeepMind and NEIL (described below) are two of the best examples of general AI, with incredible capabilities; and yet general AI is still some years off of being of true use, whilst narrow AI is currently being applied, with great results. Figure 10 below shows the different types of AI with a focus on machine learning.

Figure 10. Different types of Artificial Intelligence



Source: Robeco (2016). 'AI: Our Saviour or Humanity's Final Invention?'

Computers are able to learn retrospectively, that is, they analyse the past to spot mistakes by means of computational algorithms and use probability distributions to make assumptions, known as *machine learning*. Feeding off of 'big data', i.e. an extremely expansive quantity of data, not processable by basic software, these computers formulate adequate responses using this known past data, an example of which are Facebook Messenger's 'chatbots', developed by numerous companies, with Facebook's support and AI platform, which enable automated customer assistance tasks, such as providing information or booking a table at a restaurant without human interaction, an idea known as conversational ecommerce. Similarly, virtual assistants such as Siri (Apple) and Alexa (Google) are able to perform a variety of tasks upon spoken request, such as perform online orders or supply information.

Cognitive learning is an advanced method that is not directly a subcategory of machine learning, although it does use many techniques associated with it. It is a process that allows the machine to make judgements and handle knowledge, and therefore, make decisions for the future by imitating human thinking and considering uncertainties, through its analysis of big data. IBM Watson is devoted to the development of cognitive technologies in several sectors that range from medicine to trade, with the aim of enhancing business and professional decision-making.

Deep Learning, a method that combines machine learning and neural networks,[13] has been around since the 1970s, but has recently developed rapidly as the capacity to process data, and the

[13] Neural networks are calculation systems modelled on the biological brain, which is made of simple interconnected neurons that activate or inhibit other adjacent neurons. Thus, the system ends up by learning and training itself. This is very useful in solving problems that are beyond conventional programming. When computers were first developed, mimicking the human brain and the intelligence derived from memory was not a possibility. For example, if we touch a

abundance of data, increases. It allows learning without supervision; self-driving vehicles, for example, are gradually learning to identify and approach/avoid risks and obstacles (the system used to identify that a car must stop at a red light is relatively simple, but to acknowledge a cable that seems to be about to fall is much more complicated, and requires reasoning). In order to achieve this reasoning, robots must 'learn' from unstructured knowledge,[14] relating images and consequences, a project that scientists at Carnegie Mellon University are approaching through their NEIL (Never Ending Image Learner) robot, which is exposed to a continuous stream of images to foment association. NEIL 'knows' that cars have wheels, that zebras can be found in the savannah and that the word Columbia can refer to a university or a movie studio among others.

Although robots could replace humans in many simple manual tasks, others, which may seem simple to us, such as taking keys out of a pocket, would be too complex for any existing robot, and philosophical thinking (metathinking) would be far too complex for them.[15] However, robots can perform tasks involving massive amounts of data much better than us humans, such as voice or facial recognition and analysis of large documents. Robots do not have emotions, however, paradoxically; there are systems that can better judge human emotions than other humans, judging accurately whether a smile is false or genuine for example. There is also an app that can judge the vocal patterns of a bipolar person speaking on the phone to tell whether the person is having an 'episode', enabling them to find help if necessary, or to avoid doing certain things.

The implementation of AI to mobile technological devices, such as smartphones is called AMI (Automated Mobile Intelligence). For example, a shop assistant may rely on intelligent software in his or her mobile to analyse the purchasing patterns of customers and offer them products that match their preferences with a high rate of success.

As we have discussed, the massive collection of data available today enables analysis and processing by means of AI, facilitating decision making. AI utilises several different methods to process this big data.[16] The combination of Big Data and processing power supplies the necessary tools for AI and predictive analytics;[17] and with their progression, so too will AI advance. AI has at times, jokingly, been referred to as 'everything that robots are not capable of doing today'.

Impact and conclusions

Natural language processing has applications such a as voice recognition systems which are able to provide instructions, do translations, etc. Simple examples of this are Siri or Alexa, which are able to respond to spoken language and formulate responses, usually using internet searches. Processing usually has very specific uses, such as analysing the customers' opinions on a particular product or service, managing automated call centres, automatically searching for information in civil litigation or government enquiries, as well as drafting reports on corporate results or sports.

hot mug, experience teaches us not to do it again. Computers do not act like this, but what neural networks allow is precisely mirroring the human brain, and having the robot acting accordingly.

[14] Such as the cable example, or how to react to a drunk driver.

[15] For a better understanding on the topic, we recommend listening to the CFR discussion on AI; https://www.cfr.org/event/future-artificial-intelligence-robots-and-beyond-0

[16] This kind of software searches for relations among a number of cause-effect variables for making predictions. For example, if the data gathered shows that males from 30 to 50 tend to buy a newspaper after filling their tanks, a cross-selling process may be triggered so that the product is automatically offered, thus generating an impulse to buy. Data mining uses statistical processes to identify patterns in large sets of data, and make predictions. Some devices analyse images from supermarkets' parking lots to forecast future sales and therefore their market performance. Clustering divides large amounts of people in smaller groups to find behavioural patterns. Text analysis extracts a massive amount of information from mails, webs and written content to predict behaviours. For example, big data processing helps intelligence services to anticipate terrorist attacks in advance.

[17] Its significance is illustrated by the fact that the European Commission wants to create a common big data market with information from all Europeans. It has proposed a set of rules to store and treat non-personal data within the EU, the aim being to increase the structural productivity of both companies and economies.

Computer vision has many uses, namely, medical image analysis to improve diagnosis and disease treatment (for example Microsoft's HoloLens, mixed reality goggles, create holograms which can permit doctors to better visualise bodies and organs before an operation, or provide a hands-free display whilst a surgeon operates); facial recognition to automatically identify individuals in pictures, an example of which is the brand-new iPhone X,[18] or to estimate life expectancy; arrest suspects during security and surveillance operations; and images of products taken by the customers themselves for an enhanced buying experience. We must highlight augmented reality-driven devices.[19] General Electric's technicians use augmented reality glasses which display videos, images and texts in their line of sight to guide them when they are working on wind turbines' control panels. As a result, performance has improved by 34%.[20]

Machine Learning has a wide range of applications. It has the potential to improve virtually any activity involving large sets of data which have to be analysed and used as primary raw material for predictive models. The result is a faster, controlled and comprehensive data analysis. The financial services industry is making use of AI-related applications in its effort to control fraud and money laundering, customer knowledge and investment management. However, new technologies are spreading to other sectors and they are now being used for sales projections, stock management, oil & gas exploration, and public health – in the latter case it contributes to researching new and improved medicines.[21]

Nevertheless, AI and robotics have not yet been widely adopted, but will have a gradual impact on the economy as traditional sectors are encouraged to automate all kinds of tasks, both at office and factory level. According to some estimates, in a few years one third of the US economy could be automated by AI,[22] meaning a strong disruption for many sectors, as we will later analyse. Moreover, China is striving to embrace the robotic revolution by removing import tariffs on robots.

The figure below shows the sectors that would be more affected by AI in the next five years, according to one of the most important consulting firms in the world.[23]

[18] It promises to be able to still recognise someone even if they were to age many years. Presentation of iPhone X https://www.youtube.com/watch?v=_I7TxzdjGiw

[19] Augmented Reality (AR) is the integration of computer-generated objects or animations into the natural world captured by a webcam installed in devices such as smartphones or googles. See video: 5 awesome AR smart glasses (Augmented Reality) of 2017 https://www.youtube.com/watch?v=_Kb2I_TrP-Q

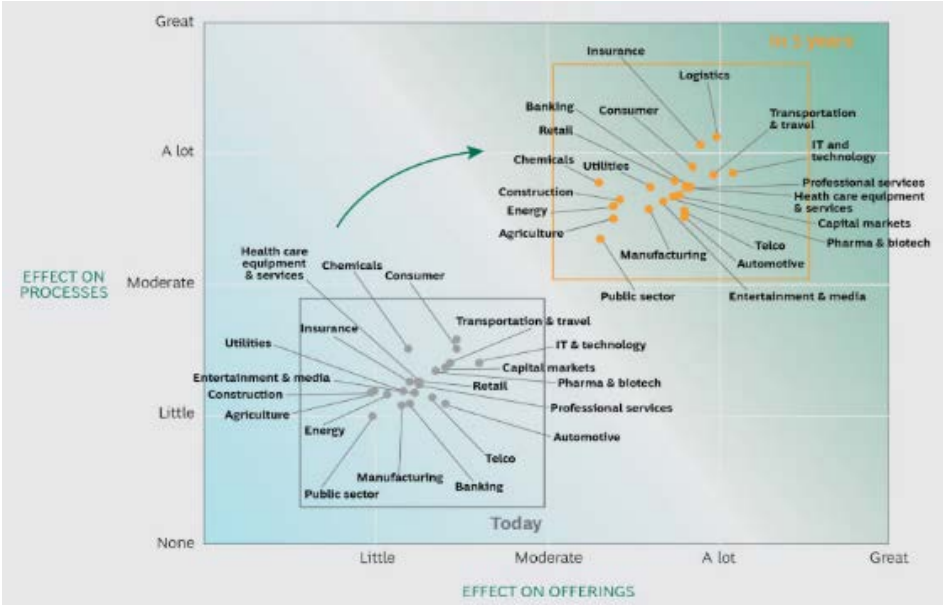
[20] Video: 'Augmented Reality is Already Improving Worker Performance' https://hbr.org/2017/03/augmented-reality-is-already-improving-worker-performance

[21] An example of machine learning would be the simplification and accelerating of the process of gathering information about customers when opening a banking account. The collection, enrichment, validation and transmission of data about the customer (identity, income and previous Jobs) from the marketing to the administrative department would be automated. Sophisticated software would manage the whole process and improve it as it learns autonomously. Enhanced customer knowledge would translate into huge savings and increased crossed selling of products (and of their proceeds) for the bank.

[22] McKinsey (2017). 'A Future that Works: Automation, Employment and Productivity'.

[23] Boston Consulting Group (September 2017). 'Is Your Business Ready for Artificial Intelligence?'.

Figure 11. Foreseeable effect of the adoption of AI by sectors in five years



Source: Boston Consulting Group (September 2017). 'Is Your Business Ready for Artificial Intelligence?'

Turing, essentially the founder of computer science, anticipated in 1950, with his 'Turing test', that we would be talking about the existence of AI when "a human judged in blind conversation with a computer could be fooled into believing it was a person". We are nearly at this stage; and it is estimated that by 2050, a computer will have more processing power than all human brains thinking at the same time. The key going forward is establishing to what extent some decisions need human emotional inputs, an aspect which could further expand the AI's capabilities, whilst also potentially creating a great moral debate, as is shown in the recent TV hit 'West World'.

Finally, and following the storyline of the abovementioned TV series, Tesla's CEO, Elon Musk, has stated that, if mismanaged, AI-driven robots could rise up against human beings and annihilate them: speaking to the National Governors Association, he said "artificial intelligence is the biggest risk we face as a civilisation", encouraging them to regulate it, ideas that were supported by Bill Gates and Stephen Hawking. Other opinion leaders, including Facebook founder, Mark Zuckerberg, expressed a much less antagonistic view (claiming that worrying about this today is like worrying about the overpopulation of Mars); inciting Musk to claim that Zuckerberg has a "limited" understanding of AI.

The platform for potentially the debate of the century has been opened.

1.2. The Internet of things (IoT)

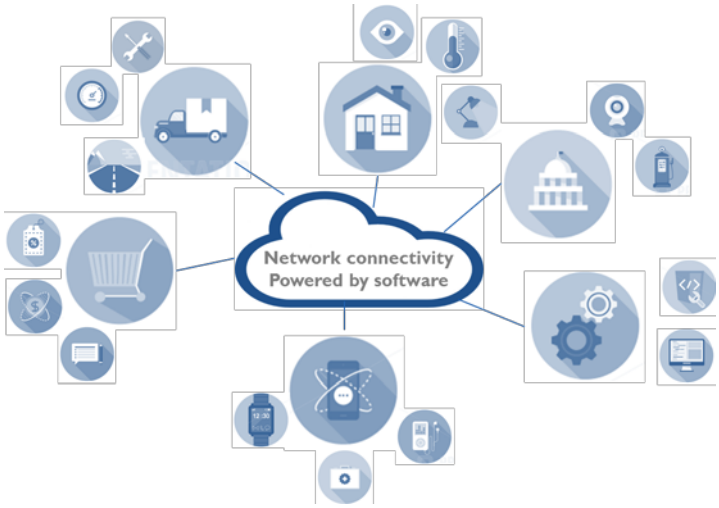
Boston is connected with New York and Washington by a high-speed railway line, a powerful economic and political route. Amtrak, the company that operates it, receives constant complaints due to regular breakdowns and delays caused by overhead wire problems. In 2015, Siemens, the German engineering company, introduced a new technology called the 'Industrial Internet of Things'. The data provided by 900 sensors installed in each locomotive, allowed detecting and solving future catenary failures, even before they occurred, with a successful result; delays were cut down by 33%.

Definition

Kevin Ashton from MIT coined the expression 'the Internet of Things' in 1999 to describe the interconnectivity, by means of sensors, transmitters and other computing devices, of everyday objects and machines, creating one large, interconnected network where data can be shared, analysed and managed (Figure 12), something which has been made possible by the cheaper sensors and improved internet accessibility. The physical state and actions of the connected objects can be easily monitored, providing the ability to efficiently manage and learn from the data collected. An example of this is 'domotics', or home automation; a smart automated home can, for example, warm up those rooms where it detects human presence, and learn the family's

behavioural patterns to heat or cool places depending on their use rate, ultimately, improving energy efficiency.

Figure 12. Network connectivity



Source: Arcano

This technology – as well as Blockchain which we will analyse later– may be highly disruptive. Blockchain, for example, allows managing smart contracts which are automatically drafted, agreed on and enforced by computers. An air conditioner may be connected to different energy supply companies and change to the cheapest provider depending on the use rate it detects and the best sale offer available, with its contracting being done automatically over Blockchain.

The 'Internet of me' is a variation of the IoT which gathers data about an individual from all the devices he is connected to in order to make his everyday life easier; personal information is stored and shared only upon previous consent. This will have profound implications. In the event of a car crash, for example, the hospital could have access to the complete medical record of the injured person simply by scanning a barcode, which would not only streamline medical care but also cut costs.

Obviously, the key 'thing' here is the smartphone, which, as we already know, is used by almost half of the Earth's inhabitants; drop in entry level prices has increased accessibility to this technology enormously.[24] Two factors have driven the development and implosion of IoT: reduced sensors' (especially, smartphones), browsing (Wi-Fi) and connectivity costs, combined with enhanced data analysis capacities.

The primary challenge that this technology will face is that of security.[25] All these 'things' connected to each other can be subject to manipulation and extortion by the so called 'Ransomware of Things' attacks. The security of things in the face of these attacks still has a long way to go, in both the technical and regulatory areas, thus greater demand for, and from, security experts will be generated.

[24] The current protocol Internet system, IPv4, has some 4.3 billion available addresses, as opposed to the new IPv6, which will provide virtually an endless amount, facilitating the implementation of IoT, since it is estimated that by 2020 there will be more than 20 billion 'things' connected.

[25] An example of the security risk associated with connectivity would be what happened in 2014 to Target. A lot of data associated with the credit cards of their customers was hacked, having been accessed through the hacking of a third party heating and ventilation company. Their network was hacked, which in turn, gave the hackers access to Target's, allowing them to copy credit card credentials of Target customers.

Uses

Sector	Uses
Homes and offices	Connected thermostats, smart conditioning, safety and lighting. Productivity improvements derived from task optimisation in offices as 'things' are able to identify inefficiencies
Transport	Early diagnosis of failures in vehicles, information about navigation, routes and safety
Retail stores	Optimisation of inventories, cross-sales, promotional products based on personal profiles
Personal mobile apps	Smart watches which provide information on heartbeats, disease detection, sleep quality etc.
Industrial Internet	Real-time analysis of processes for sustained improvement, factory automation and supply chain systems
Cities	Traffic lights, smart parking and ticket machines, meter boxes, traffic management, safety, etc.

Impact and conclusions

Improved health and life expectancy: IoT will contribute to improved human health, since the connected devices will be able to 'learn' from our behavioural and vital patterns, by detecting anomalies at an early stage, which could translate into heavy cost savings for the medical industry. For example, clothes are being developed that incorporate sensors that are able to detect if you are about to have a heart attack, and even apply pressure to the chest to reduce the impact.

Improved factory efficiency: value from the IoT would be derived from enhanced energy efficiency and workforce productivity, the optimisation of equipment maintenance and stock management, and better worker health and safety.

City optimisation in three main areas**:** transport (management of traffic flows through the installation of sensors that detect traffic jams), public health and safety (sensors that check location and intensity of toxic air pollutants) and resource management (reduced loss of electricity in distribution and sensors that detect water leaks, among others).

By 2025, IoT could have an estimated impact on the global economy of 3.9 to 11.1 trillion dollars[26] per year, a wide, but very significant range. This impact is measured by the potential benefits it may generate, such as improved productivity, time savings and asset utilisation (longer lifespans, reduced inventories), as well as the economic value derived from reduced disease, accidents and deaths.

The more devices connected, the more tasks optimised: objects will hardly get lost, and food or medicines wasted because they had reached their expiration dates. The most notable risk comes from safety, since the large-scale connection of devices may make them too vulnerable to potential attacks, as happened in October 2016 when many companies were affected by a widespread malware attack (ROT). On the other hand, adoption of this technology will depend on the capacity to gradually reduce access costs, and to standardise connection protocols so that it becomes compatible with most devices. However, these challenges seem rather ambitious for the time being.

1.3. Autonomous vehicles

In 2015, the mining company Rio Tinto announced the launching of a programme to replace all trucks operating in two of its Australian iron ore mines located in Pilbara, to be replaced by self-driving vehicles (Figure 13, L). The company also tested self-driving trains amongst other automation-related technologies, with the aim of cutting costs and increasing efficiency and safety. It was considered that the performance rates of autonomous vehicles exceeded that of human-driven fleets by 12%; through the avoiding of employees' coffee-breaks, absenteeism and pauses for shift changes. Similarly, several companies have got licenses to test driverless long-haul freight trucks in several US states (Figure 13, R), the US is passing a law, supported by both

[26] McKinsey (2019). 'The Internet of Things: Mapping the value beyond the hype'

major parties, to homogenise and accelerate test permits for autonomous cars, which could reach up to 100,000 a year.

Figure 13. Driverless trucks working in the Australian mines and on a road in Nevada

Source: Google

Types of autonomous vehicles

Autonomous vehicles can be classified according to the degree of operation required from the passenger[27] (Figure 14).

Figure 14. Potential level of automation at self-driving vehicles

Source: SAE International; National Highway Traffic Safety Administration

The combination of camera sensors (something which is already in place, and which provides them with 'eyes' with which to see other cars, traffic lights, passers-by etc.), LIDAR technology (which allows vehicles to send and receive laser pulses to detect and be aware of the objects that surround them), and a simple radar opens up many possibilities for improved driving in a context of autonomous vehicles. The information supplied by LIDAR technology is much more accurate than that of the human eyes and brain.[28]

In any case, as mentioned, we are still many years from fully autonomous cars being introduced on the streets, with technology to provide 'common sense' and react to random events, which occur very frequently in reality, still some way off from being reliable enough to risk human safety. In the case of a drunk driver also being on the road for example, an autonomous car would not know to proceed with extra caution, prepared to manoeuvre should he swerve. Similarly, with the prior example of the cord hanging over the road, a human driver would know to slow down or stop entirely and find a new route, unlike an autonomous car; it also seems that graffiti on walls tends to confuse the AI systems of autonomous cars. One test rider of a self-driving car noted that it was similar to "being driven by [his] 18-year old son who had only just got his license".

[27] This classification was proposed by the Society of Automotive Engineers.
[28] The only exception is fog, which cannot be properly detected by sensors.

Moreover, when first introducing driverless cars on the road, it is important to consider that this may confuse other drivers, who may be put off by the lack of someone behind the wheel; for this reason, Ford has recently sent cars on the road with drivers disguised as car seats. The reasoning behind conducting this was two-fold; to test public/other drivers' reactions to a self-driving car and the communication being via light signals rather than hand/facial gestures, and to help promote adjusting to the future of autonomous cars. In the short term, it is only viable to introduce autonomous cars in safe, low-speed and relatively controlled settings, with golf-car-type vehicles to be used in places such as nursing homes, industrial estates, public parks and golf clubs. Only with further technological optimisation will the autonomous car start to, and eventually entirely, displace professional drivers of any sort, making them a complete non-necessity, as occurred with lift operators. Already the effort of knowing routes for journeys is superfluous, with GPS and applications such as Google Maps calculating the best route, while taking into account live traffic conditions.

Uses

Transport of goods: most studies broadly agree that autonomous vehicles will be mainly used for transporting goods, where cost savings may be substantial. However, this will have some major labour implications; in the US truck drivers make up over an eighth of jobs in opportunity occupations (occupations paying at least national median wage available to workers without a bachelor's degree), with nearly three million employed in the industry,[29] whilst also indirectly generating many other jobs. All in all, cost savings are expected to be major, tantamount to the total annual pension schemes allowance, so there would be enough leeway and resources to implement policies to ease job disruption. Uber has been making moves into the autonomous trucking area, with its acquisition of Otto in 2016, and its completion of the first commercial shipment by self-driving truck; delivering a trailer full of Budweiser after 120 highway miles.

Autonomous car: a fierce battle has begun between Apple, Uber, Google[30] (through its subsidiary Waymo), Lyft,[31] Ford, Tesla and Daimler for the pole position in the autonomous vehicle market. Foreseeably, only a few can win the game, and the winner could take it all. This situation may have substantial implications. Uber is currently valued at between 50 and 70 billion dollars, with a license which does not include owning their driver cars fleet, if Apple were able to become the first company to popularise driverless cars for urban transportation at a very competitive cost (which is a likely scenario since drivers are still Uber's highest cost), Uber's valuation could vanish entirely. As we will discuss, the development of the autonomous car may bring drastic changes for our cities.

Impact and conclusions

The main advantages derived from autonomous vehicles may be:

- A reduction of 90% in road accidents,[32] which would help cut insurance premiums and medical assistance costs
- Improved productivity, with less time wasted with transport (commuting)
- Lower car purchase and sale volumes with subsequent cost savings. On average, cars are only used from 3 to 5% of their service life, since most of the time they are parked; whereas shared economy vehicles, such as Uber's, are used nearly 60%
- Increased efficiency of smart vehicles due to lighter traffic and better parking alternatives
- More spacious cities as lots of parking places will be redundant, and so replaced[33]
- Increased mobility for those who cannot drive, such as disabled and old people
- Reduced energy consumption

[29] 2% of total workers and the most common job among white males, with its subsequent political implications.
[30] Google showcases its latest prototype of self-driving car:
https://www.theguardian.com/technology/video/2014/may/28/google-self-driving-car-spin-video
[31] Lyft is Uber's primary competitor and its project has recently been heavily supported by General Motors and Tata motors (Jaguar Land Rover).
[32] KPMG (2017). 'The Chaotic Middle. The autonomous vehicle and disruption in automobile insurance'.
[33] Parking lots may account for some third of cities' underground space.

The advantages derived from the adoption of self-driving vehicles have been estimated at some 10% of GDP, half of which would come from productivity improvements and half from the reduction of medical care costs.[34]

The principal potential disadvantages could be:

- Job disruption, especially for taxi and truck drivers, loss adjusters,[35] hospitals, car repair shops, etc.[36] However, new jobs would also be created associated with the new cars and their maintenance service data treatment. Repair shops will have to work at a quicker pace and be in prime locations. Sharing economy will noticeably increase the average utilisation rate per car used
- Safety-related risks when cars are interconnected, especially in the transition period, when both autonomous and non-autonomous cars are on the roads
- Increased costs derived from connectivity (cameras, GPS, etc.)
- Decreased local tax collection, since surface and underground parking lots will disappear
- Legal uncertainties: who is responsible for a driverless car accident?

In any case, research highlights that advantages outnumber disadvantages. The psychological impact should be anticipated, though. As a matter of example, New York City introduced automated subway trains some time ago, that were later replaced by humans. We must bear in mind that as important as having the technology is its rate of adoption, which requires a suitable regulatory framework. In this sense, the available 5G technology allows cars to be connected both with each other and with the networks, so that they can learn from data.[37] This is useful for automatically avoiding traffic jams or to arrange linked convoys of vehicles – the so-called platooning – which would increase road transportation capacity as well as energy efficiency.

We must note that technology adoption is expanding more quickly due to the coincidence in time of a number of factors:

- The progress made on electric vehicles is noticeable
- Connectivity is advancing at a swift pace
- Autonomous driving is increasingly reliable
- Car sharing and similar mobility alternatives are gaining on car ownership[38]

Some countries are more advanced than others, such as Germany, Sweden or Korea, but in any case, disruption is not expected to speed up before 2025. A high-disruption scenario implies that by 2030, only 30% of new vehicles would be fully autonomous. This percentage would increase to 50% by 2035, and reach 90% by 2040,[39] potentially creating a market of near 7 trillion dollars. As we have already mentioned, the migration will first impact the transport of goods. Only seven years ago, in 2010, autonomous cars were not even a prospective reality, and electric cars were being ridiculed; so much can change in so short a time. The combination of powerful algorithms, cheaper (and more powerful) sensors and increasing processing power will continue to accelerate progress.

1.4. Blockchain, Bitcoin and ICOs

Blockchain

The disruptive Blockchain technology is nothing more than a transaction log. It was created by a person (or group) under the alias Satoshi Nakamoto with his introduction of Bitcoin. It has the potential to entirely redefine the way any kind of transaction is processed, from real estate properties to UN donations or vote counting, showing a huge potential for revolutionising

[34] For example, every year 40,000 people die in the US in traffic accidents, the number of hospital patients being significantly larger.
[35] Only in the US, there are some 300,000 car accident loss adjusters.
[36] Those sectors that are somehow related to car crashes are called *The Crash Economy* in the US.
[37] Uncertainties will arise regarding who owns the data; the car manufacturer, the passive driver or the insurance company.
[38] McKinsey (2016). 'Automotive Revolution – perspective towards 2030'.
[39] McKinsey (2016). 'Automotive Revolution – perspective towards 2030'; Morgan Stanley (2013). 'Autonomous Cars. Self-Driving the New Auto Industry Paradigm'.

interaction between actors involved in the transactions. It has been argued by some that Blockchain may be the most disruptive technology since the emergence of the internet, since it could safely allow the execution of all types of transactions and immediate, direct payments, greatly reducing transaction costs, as well as traceability of all types of information, such as the identity of individuals, educational titles or verification of home/land owners.

A greatly simplified definition is that it is a technology that allows the management of a comprehensive, decentralised record of transaction, keeping an online ledger or database, through the use of internet and encryption, creating total trust between parties since any information can be verified:

- It is neither managed nor watched over by public or private institutions – that is, governments or banks. Therefore, it is a decentralised system – a feature increasingly welcomed by societies, whose population's discontent towards the power of governments and financial institutions has seemingly grown
- It keeps a record of each and every transaction carried out among its participants in a distributed ledger amongst all participants in the Blockchain, with no one centralised base, thus providing the ability for verification
- It is very transparent and safe,[40] so it provides a more reliable option for those who distrust centralised management solutions, with data of who owns what accessible to all. Moreover, it is impossible to alter the information without the previous consent of the other party. Safety is guaranteed by means of an advanced cryptographic and algorithmic system, sophisticated mathematics and incredible software power[41]
- Intermediaries are avoided throughout the process, thus enabling the so called smart contracts, which are generated and enforced automatically by means of a program (algorithm) without the intervention of the parties. Smart contracts may be heavily disruptive for the legal sector, as we will see in the sectoral impact section

Although Blockchain's potential is enormous, its full potential has not been yet tested on a large scale. Its current, most popular application is processing bitcoin-related transactions, the most prevalent virtual currency globally, which given the degree of anonymity it provides may be used for money laundering purposes, prompting strong reactions and the recent closure of Bitcoin markets in China. Nonetheless, some 20% of the global population (1.5 billion people) do not have access to the financial system yet. Blockchain could radically change this situation and contribute to eradicating poverty, which is closely related to lack of access to the financial system. For everyday purchases, Blockchain will allow us to check whether the cinema ticket we are buying is genuine or not, since its origin could be traced,[42] allowing to digitally exchange the ticket and its cost. It would take seconds to make an international payment, and at zero cost, although as we have already mentioned this application is still in its early stages. Bitcoin can process from five to eight transactions per second, whereas in the case of credit cards the figure goes up to 10,000 times that amount.[43] On the other hand, this technology still lacks a regulatory framework and potential security risks are still to be seen.

Nevertheless, it is highly valued by experts given its huge disruptive power. It is just a question of time as to whether it will take off and fully confirm its impressive potential. It could be used

[40] Blockchain works as follows: when a digital transaction between a buyer and a seller is carried out, it is recorded in a block with a code stating the exact time it was done, and grouped together with other transactions. When an established amount of information is reached, the block is validated. This process requires a highly sophisticated cryptographic system with strong levels of computing power to generate the number that will allow to validate the block, send it out to all connected computers and guarantee that it cannot be neither changed nor altered. The group of connected computers required to calculate the number is called a 'mine', and the members in the network operating it, 'miners'. They are usually based in countries with low energy prices, such as Russia or Venezuela. In the bitcoin Blockchain network, the miner that generates a number and validates the block receives a bitcoin as reward. At present, some 25 bitcoins are generated every ten minutes.

[41] However, we must note that Blockchain encryption may not be perfect and safety-related issues could arise in future. In fact, the cryptocurrency Ethereum has already suffered a hacking attack. Blockchain can be tested in what is called a sandbox – literally, a playground – which seem to have been attacked too. Therefore, although Blockchain is considered very safe, it may still be vulnerable.

[42] Among the advantages of Blockchain's traceability is that it may help combat the trade in blood diamonds. Nowadays, a large amount of traded diamonds are no longer blood ones.

[43] Goldman Sachs (2015). 'What if I Told You…'.

to largely simplify the process of buying shares. Today, it is possible to buy stocks in just one second. However, the settlement process (delivering the code of stock ownership in exchange for the money) takes place two days later, thus tying up large amounts of money and entailing complex procedures. Many retail banks, and some central ones too, are working jointly to create a cryptocurrency that could have a 1:1 parity against the dollar, thus reducing the settlement process to a split second, with the subsequent savings and release of cash.[44] The same concept applies to checks, why is it possible to receive an email in just one second, but it takes days to cash in a check if the process consists in changing some digits in two banking accounts? An out-of-date settlement is the reason again. Blockchain will revolutionise this, although the process will be gradual.

We will not analyse in depth the uses or the largest impacts of Blockchain, but we summarise them below so that our readers can be aware of its full potential.

Uses	Impact
▪ Purchase and sale of financial assets and currencies ▪ Corporate servers and software license optimisation ▪ Identity authentication[45] ▪ Cloud-based data storage ▪ Contract enforcement. Smart contracts[46] ▪ Digital balloting and vote counting ▪ Method of payment: transfers, cards, remittances, etc. ▪ Property registry[47] ▪ Medical history records ▪ Data records of any big data mechanism ▪ Public service supply to reduce fraud, avoid mistakes, cut operating costs, facilitate tax collection, manage identities, distribute subsidies and keep records (real estate property…)	▪ Increased speed and reduced costs of customer transactions since the number of intermediaries is rather limited. Transparency and safety are also enhanced. Large impact on the financial (methods of payment, brokerage), real estate (purchase and sale of real estate properties) and energy (individuals will be able to commercialise their spare capacity) industries. It could mean the end of some businesses, such as betting games ▪ Diminishing operating costs for the financial system in areas such as back office (fund management) or risk appraisal (loan granting) ▪ Improved efficiency of the supply chain (process optimisation) ▪ Greater protection of innovation protection since it hinders the copy of patents ▪ Current investment: 1.74 billion dollars,[48] 796 million in 2016 ▪ Economic impact: 176 billion dollars in 2025 and 3.1 trillion by 2030[49]

Bitcoin

Bitcoin is the world's most popular virtual currency. It was created in 2008 as the logical reaction to the large-scale money printing undertaken by central banks during the crisis, which led to the economy being affected by an undeniable medium-term inflation risk, which prompted the search for safe-haven currencies away from the control and dangers of central banks.

[44] The possibility that central banks start issuing cryptocurrencies for public widespread use is also under discussion. Although it would expedite and reduce the cost of traditional means of payment between the parties (who could have their accounts in the central banks themselves), they could entail a severe liquidity risk in the banking system (they would not have commercial depositories, but rather, would work through the central banks, providing more stability and security), so loans granted would have to be financed by central banks too often. This would mean that the public authorities, i.e. the central banks, would have the final say in the money creation in the system, rather than the market forces of the banking system. The system's efficiency would be at risk -attempts were made in the former Soviet Union with skyrocketing inflation, since the political power raised significantly the systems liquidity.

[45] Microsoft and Accenture have developed a Blockchain-based system to identify refugees: http://fortune.com/2017/06/19/id2020-blockchain-microsoft/

[46] A smart contract is a computer protocol with a fix set of terms agreed by the parties intended to facilitate the performance of a contract. As a matter of example, in an equity transaction there will be two blocks involved, one in charge of tracking who owns the stocks, and the other, who has the cash. This allows the buyer to transfer the stocks, and the seller, the cash.

[47] The Swedish government is successfully carrying tests to record real estate transactions through Blockchain. As soon as it is fully tested and fine-tuned, it is expected to be implemented in other EU countries soon after. Brazil, Ukraine and Georgia are also testing this Blockchain functionality. Dubai has pledged to run all of its government services and transactions data on Blockchain by 2020.

[48] Financial Times (June 2017). 'Growing scepticism challenges the Blockchain hype'.

[49] Gartner report (technological consulting).

Despite this consistent conceptual explanation that depicts bitcoin as a sustainable currency with significant future growth potential, its limited volumes prevent it from properly competing with the world's main currencies as a method of payment. In some cases, it has been used for tax evasion, money laundering or capital flight derived from the anonymity provided by the Blockchain technology. Its use is more widespread in countries ruled by corrupt regimes or with higher degrees of capital control. Moreover, its high trading volatility and valuation, in bubble territory, hinder its extensive use as a value deposit or method of payment. As for volatility, we must note that early in 2017 it was trading at close to 1,000 dollars, in June, it went up to 3,000, dropped down to 2,000 one month later, perked up to 5,000 at the beginning of September, and slumped to 3,000 by the middle of the month – shocked by China's decision to significantly reduce bitcoins operations in secondary markets. As for the bubble, many renowned economists have warned about it. Most recently, Jamie Dimond, JP Morgan's CEO, said to the media that bitcoin was a fraud only comparable to the tulip mania that took place in The Netherlands in the 17th Century, considered to be the first recorded speculative bubble in history. Although it is a complex exercise, some analysts have indeed tried to value bitcoin just to conclude that the bubble is a fact, and that the virtual currency is overvalued by 264%. BitVal, the valuation model, is based on its purchasing power parity and in the estimated amount of money laundering taking place at any given moment in time.[50]

Anonymity in cryptocurrencies raises the potential for use in illegal activities, a problem which many are trying to tackle. Moreover, states have been in charge of currency supplies for hundreds of years and the appearance of a parallel network may have unpredictable consequences. That is one of the reasons why China has curbed the use of Bitcoin. The limited supply of Bitcoin and its rising demand could be fomenting the creation of a bubble. As the Bitcoin price rises, the value of the goods that can be purchased with this cryptocurrency deflates. Deflation may be dangerous, as seen in Japan, and governments combat it by issuing money. If they lose the power to do so and Bitcoin were the only currency in circulation, a deflation and a subsequent crisis, similar to that of 2007, would take place, and no software can be programmed to avoid it. Moreover, two thirds of Bitcoins are stored and not used, something which could have negative consequences for any economy. Anyhow, similar currencies are emerging, such as Ethereum, which also uses Blockchain technology. These technologies will make possible paying without using credit cards; Apple, Bitpay and Pay Pal are already developing projects.

ICOs (Initial Coin Offering)

ICOs are a means to raise money used by advanced technological developers linked to Blockchain platforms. A main feature of investment in these types of cryptocurrencies is that they use restricted-use tokens, which are bought in exchange for funds for financing the launching of technology ventures. The token provides its holder access to and use of the project once it is launched and operating. The investment pays off when the project succeeds, either because the capital value of the digital token rises, because customers are required to pay in tokens, or out of mere speculation. The process is rather unregulated and somewhat reminds us of the internet boom in the stock markets at the beginning of the 21st Century. At that moment, it was already assumed that the internet would have an enormous impact on the economy, but it was not that obvious which projects would succeed. Incidentally, most misfired, causing the investments to lose all their value, whereas those few that did succeed took a large share of the pie, which generated colossal returns in the stock exchanges (Facebook, Amazon, Google…). In short, the risks are elevated and the scenarios, too binary – high chances of losing everything, and scarce possibilities of obtaining substantial gains). For these reasons, ICOs have been described as "financing the building of a casino with tokens which can be only used to gamble at that casino".

[50] Financial Times (2017). 'How to value bitcoin with a traditional valuation measure'.

1.5. 3D and 4D printing technologies

3D printers

The 3D printing sector is still some way off its full maturity, but some signs indicate that it could pave the way for a new industrial revolution. 3D printing is the process of producing objects by printing layers of material based on digital models. Traditionally, they have printed in plastic, but new materials, such as gel and metal, are being developed. The use of these materials will contribute to shortening manufacturing times (with savings of up to seven times), with the subsequent reduction in costs.

The main disruption caused by 3D printing is that of potentially fundamentally altering existing supply chains, which could reduce dependence on outsourcing for both materials and labour to emerging countries, a fact that has encouraged countries such as USA, China and Germany to greatly invest in this new technology. For example, today, the iPhone case we buy will have been manufactured in China from Oil from the Middle East; 3D printing would enable printing your own case in your house, with materials sourced locally.[51]

The same thing will happen when we print our Nike shoe ... it may not be long before in-home printers are able to do a similar job, causing a huge global disruption. This 'home' phenomenon is called 'Consumer 3D'.[52] In addition, 3D printing can allow you to print disparate objects, such as a heart,[53] food,[54] houses or spare parts for spacecraft. Boeing is using 3D printers for over 5% of the 6,000 parts for their 747 planes; the company is aiming to increase this number to 50%, drastically reducing the weight of aircrafts and thus reducing energy consumption, with Airbus looking to follow in their steps. Therefore, 3D printing will foment the move away from Oil. This large scale industrial method is called 'Professional 3D'. The big question that remains is, how will patents be regulated? Currently you can download many designs which can be easily printed, infringing on copywriting.

As in the case of Blockchain, we do not thoroughly analyse this technology, however, we have made note of some of its uses and potential impacts.

Applications	Impacts
▪ Manufacturing production ▪ Car, ships, spacecraft and aircraft components[55] ▪ Construction[56] ▪ Plastics industry ▪ Mechanical and industrial engineering ▪ Pharmacology and medical supplies (prosthesis, organ printing, etc.)[57] ▪ Consumption goods	▪ Efficiency improvements (cost cutting in the production process) and acceleration of product development cycles in the affected industries ▪ Construction: reduced labour and supplies costs, and, subsequently, prices. Increased global affordability levels ▪ New manufacturing production strategies: highly customisable and easily repaired products ▪ Stock reduction derived from quicker and more customised production ▪ Sustained development as a result of reduced pollution rates, derived in turn from the reuse of materials ▪ 2016 market impact: 6.063 billion dollars.[58] Forecast for 2025: from 200 to 500 billion dollars[59]

[51] CFR's conference on AI: https://www.cfr.org/event/future-artificial-intelligence-robots-and-beyond-0
[52] In-home printers can now be bought for under 500 dollars.
[53] https://www.youtube.com/watch?v=pd3TFB0wOI0
[54] A NASA project to provide more palatable food for astronauts has already showcased its printing of pizzas, but is in the process of optimising and improving this. In the future, it may be possible to create meat products without killing animals.
[55] BMW has already manufactured 10,000 accessories and other brands as Renault are following suit.
[56] 3D homes have been printed in less than 24 hours: https://www.youtube.com/watch?v=GUdnrtnjT5Q
[57] Missouri or South Carolina's Médic5 universities conclude that "printing or computer-aided layer by layer biofabrication of tissues and organs is technically feasible".
https://www.researchgate.net/publication/5695608_Organ_printing_Promises_and_challenges
[58] Wohler report (2017)
[59] McKinsey (2013). 'Disruptive Technologies: Advances that Will Transform Life, Business, and the Global Economy'.

4D printers

4D is a new printing process under development, where time is the fourth dimension. The process is similar to that of 3D printing, however, the printed objects are comprised of unique active composites whose architecture is carefully designed to include precise locations of shape-memory fibres that will behave a certain way when exposed to external stimulus, such as temperature changes, and 'morph' into their predetermined shape. These are its potential impacts:[60]

- Architecture: 4D materials for automated ceilings and facades which change according to light and heat conditions
- Bio medicine: resins to mimic bone marrow tissues, and medicines which administer the dosage at the appearance of the first symptoms
- Trade and transportation: materials manufactured and transported in a flat shape, and then later have their designed shape activated on site by a specific stimulus
- Infrastructure: programmable and adaptable pipelines

[60] Skylar Tibbits: 'The emergence of 4D printing'
https://www.ted.com/talks/skylar_tibbits_the_emergence_of_4d_printing?language=es#t-39010

2. Sectoral Impact

Having analysed three disruptive technologies in detail, and discussed two more (Blockchain and three and four-dimensional printing), we now explore the potential impacts that such innovations might have for a number of sectors, as well as for the economy as a whole. Given its greater complexity, we have excluded the commercial banking sector.

2.1. Insurance

The insurance sector will be heavily affected by various technologies, both in the life insurance area as well as the others. In **life insurance**, remarkable new AI technology is using facial recognition to calculate life expectancy, providing the potential for more accurately optimised actuarial calculations for prospective clients. For example, a new US company, Lapetus, believes that a simple selfie can replace much of the medical / actuarial process necessary to calculate life expectancy. Customers could email their best self-portrait photos and computer systems would take care of the rest: scan the image and analyse the thousands of different areas of a face. They not only look for basic information such as gender, but also clues about how quickly the person is aging, their body mass index and whether they smoke. Equipped with this information and some complementary information from customers, Lapetus believes that the system's prediction of life expectancy is much more accurate than traditional methods, and the process would take only a few minutes.

AI will also be relevant in other areas of insurance. AI and autonomous vehicles will greatly alleviate **car and auto insurance** chores related with traffic accidents, thus causing a huge loss of jobs, as previously discussed. If the emergence of the autonomous vehicle brings about the expected reduction in the accident rate, and contributes to reversing the tendency towards car ownership in favour of car renting or single ride purchases, the industry will undergo a heavy contraction. Moreover, AI may help to prevent insurance claims fraud, with data being generated by every piece of property, which would be accessible by the insurer, who could assess what went wrong and how much damage was done. As for **agriculture and farming insurance**, new applications are being developed; Aerobics is already using an application which allows for 3D mapping of the ground to control crops' health from the air. The use of big data, mapping technologies and machine learning will help to better analyse, and thus prepare for, potential natural disaster risk, from small-scale flooding to large-scale disasters. Finally, **health insurance** could also experience major disruptions, as discussed in greater detail below, with advances in healthy living, medicine and longevity.

The insurance industry could see its historic business model revolutionised by Blockchain technology. The certification of data integrity analysed in the processes and the new products that have arisen thanks to the new technology will be the main tools of change. The 'Smart Contracts' will greatly expedite the processes, given that an action, such as the sending of relevant private information, the transfer of an asset, or a payment, will occur automatically at the time stated in the contract; cutting out intermediaries through the use of autonomous software. These could be used to generate 'use-dependent' insurance contracts, whereby insurance will be paid by hour of use, rather than annual; cars, for example, are only used on average for 3% of their life – this could lead to a great reduction in the volume of insurance businesses. Finally, the internet can facilitate the methods of obtaining premiums and filing claims, as the Chinese insurer Zhong An, which has recently been offered on the stock exchange, with a valuation of 10 billion dollars, has shown.

2.2. Asset and Wealth Management[61]

The **asset management** sector (investment funds, pension funds etc.) will also undergo a major transformation. We have seen how passive management funds (ETFs) have gained popularity in recent years, replicating the indices at a very low cost, and gaining market share over traditional active management. For a long time, quantitative strategies have been disrupted by active investing, but human interaction is limited;[62] Blackrock, for example, dismissed more than thirty employees of its main active management funds.

These strategies have been developed over the last several years,[63] with varying success; however, the adoption of AI could be a major blow to quantitative management. One specific example is how satellite image recognition techniques can detect the volume of container activity in the ports most used by Indian automobile components manufacturers, which can then be used to study the relationship between the number of observed containers and the expected number needed to produce a positive turnover for listed companies, when variations are detected the algorithmic machine can decide to buy or sell shares. Similar techniques have already been used in the past to detect billing volumes between US distribution companies such as Walmart, based on photos of parking areas in their centres.

Quantitative investment strategies have long tapped into these increasingly powerful systems to try to find statistical signs of profitable investment opportunities. But machine learning goes a step further; in essence, a machine learning algorithm is a dynamic tool that analyses a large amount of data (big data), such as stock prices, weather patterns, transcripts of company results presentations, Facebook comments or Google searches, trying to draw a pattern of behaviour that allows it to make reliable predictions (it is the so-called algorithmic trading).

A machine learning algorithm will evolve and automatically look for new patterns, adjusting to what works best in the markets that day, week or year. This means that asset managers can use it as a tool to improve their investment process, perhaps by detecting patterns undetectable by humans, or even to develop strategies and let them execute them by themselves based on massive data processing.

Figure 15. Photo taken in real time in a commercial port

Source: Google

In **investment advisory**, automation has been developed through the use of robo-advisors; investment management tools that autonomously design and manage a financial portfolio of an investor, usually via capital allocation between various investment funds profiled by risks and

[61] This is the only financial-related business line we deal with in more detail since we have excluded the commercial banking sector as a whole from this report. However, we must state that AI (machine learning) will bring about substantial benefits to a number of processes such as account opening, the fight against fraud and money laundering, the continuous KYC monitoring ('Know your client'; knowing and identifying the identity of clients) and management of loan granting documentation.

[62] In fact, these types of strategies were greatly the cause of the 1987 stock market crash

[63] Smart Beta, Factor Investing, Algorithmic Trading etc.

assets. Robo-advisors study and learn the risk tolerance of each client, processing a multitude of relative valuation data, on which build appropriate portfolios for each profile; a type of work that until now has been performed by human beings in the private banking and personal banking sectors, but now can be done more cost efficiently, with fewer errors and conflicts. The technique is not new, but the more powerful systems mean that their application will be much more effective and efficient. Artificial intelligence can help to find patterns of behaviour that a human would never see, providing an important advantage.

2.3. Retail Sector

The distribution sector will see important changes in its current supply chain as autonomous trucks take to the street in the next few years. Moreover, customer experience is also changing, with AI already being used to help with the choosing of products, various algorithms have been implemented by most online retailers and advertisers. Additionally, physical robots are coming into place, with certain retailers introducing them in shops, such as the previously discussed, Carrefour. Their introduction of *Pepper*, a humanoid robot created by the Japanese company SoftBank, in 2015 into three of its French and two of its Spanish stores, are used, for the moment, purely for welcoming customer, providing them with light entertainment and offering advice on discounts, promotions and new products.

Robotics in the broadest sense of the term – encompassing not just humanoid robots but other devices that can perform tasks generally thought to exclusively be done by humans – is about to become an essential part of the retail distribution business. It will not be long before robots and computer systems replace human beings in inventory management, promoting products, analysing customer preferences, facilitating automatic payments, arranging deliveries, and many other tasks. In fact, Amazon stores are a gigantic testing ground: with robots being implemented in nearly all phases of their distribution system, from product selection to delivery. Their 'kiva' robots can carry shelves weighing up to 750kg each and greatly speed up item selection.[64] Amazon has also introduced a new initiative, Amazon Go, which consists of supermarkets where someone can scan their Amazon account to get in, pick up the items they want, and walk out; using sensors[65] and AI algorithms their purchases are automatically charged to their Amazon accounts. This will not only greatly speed up time spent shopping (with the omission of any time wasted in queues), but will also affect shop assistants, a job that already is being affected by the introduction of self-check outs. Today Amazon is worth double WalMart and five-hundred times the American retailer Sears – a clear illustration of the already evident technological disruption of e-commerce.

The job of restaurant waiters is another example of the scale of disruption in the retail distribution sector. The risk that they may be replaced by a simple tablet is not negligible; customers would use them to order and would then be served by robots; a system that is already in place in some restaurants. The implications may be substantial for countries like Spain, where the restaurant business has a significant weight. For those countries whose economies are highly dependent on tourism, technology may mean increasingly optimised and more profitable businesses, but also social tensions.

2.4. Legal Sector

The legal profession will experience serious disruption as a result of automation, and it has been estimated that almost a quarter of jobs in the sector are at risk of being automated,[66] AI will optimise the huge work involved in data analysis and documentation when a case is opened, both in internal and external processes, that is, as far as legal transactions are concerned.

As for internal processes, Lexoo, a UK start up, does not automate legal work, but rather, helps to optimise legal fees for companies or individuals in search of legal advice by assessing quotes and finding the best specialised lawyer taking into account success rates, case history and

[64] Link to video showing automated robots used in Amazon logistics: https://www.youtube.com/watch?v=UtBa9yVZBJM
[65] https://www.youtube.com/watch?v=NrmMk1Myrxc
[66] McKinsey (January 2017). 'A Future that Works: Automation, Employment, and Productivity'.

transparent fees. Similarly, LegalZoom is an online legal advisor that also offers the ability to automatically generate drafts of various types of contracts.

An American start up, Lex Machina, is able to process huge archives of data at an inhuman rate, cross examining data on the judiciary, the client's case and past outcomes, predicting case success rate and replacing many of the tasks usually performed by lawyers, even the most qualified ones. Applications such as Turbo Tax American are helping millions of Americans to resolve queries they might have with regards to tax law, saving them the time and cost of soliciting a tax attorney.

At Berwin Leighton Paisner, a UK company, employees use an AI system when working on certain property litigation. The system was developed by RAVN a start-up that extracts data from the official records of the property. The software allows you to use these details to put together legal notices for the actual owners of the property in cases of property dispute. While earlier, younger employees could take weeks on a similar task, the AI system performs the process in minutes. Ravn's technology seeks, to a large extent, unstructured data to obtain and summarise very specific information. The legal sector is a perfect client because it is intensive in document search and processing.

Regarding external processes, *smart contracts* may be of great help in international agreements.[67] Their computing codes will automatically articulate the different stages of complex agreements basing on objective criteria previously agreed on by the parties. Smart contracts will most likely become self-enforcing tools that will even solve issues related to the automated enforcement. For example, in a Blockchain car buying transaction, if the buyer defaults, the car will cut out automatically. Lawyers and judges will no longer be needed to enforce an agreement, with the subsequent sector disruption. In the future, many lawyers will need some kind of engineering background, something which is already happening in patent law, with the so-called patent engineers. Moreover, the technology used by Blockchain is expected to replace the current electronic signature due to its increased reliability and lower costs.

Finally, the disruption brought about by Blockchain will have an impact not only on law firms, but on the legal sector as a whole. A decentralised system entails not being subject to a specific jurisdiction, thus huge uncertainties may arise regarding the applicable law. Furthermore, a decentralised system will allow lots of companies to outsource many departments. Blockchain may also contribute to creating a new legal entity already under discussion at the European Parliament, the 'electronic legal entity', subject to rights and liabilities. There might even be robots who are 'electronic legal entities' and have no owners.[68]

With regards to patent law, the revolution associated with AI is in full swing. It is estimated that more than three-quarters of the litigation on the subject is solved by algorithms, a great deal of which is done through eBay.[69] Algorithms are able to process great quantities of data of similar disputes in order to produce decisions considered to be as fair as possible. Their use for other disciplines has only just begun, which affects arbitration and, ultimately, the judiciary.

In reality, of course, there are many skills of qualified lawyers that arguably cannot be replaced by AI, such as appealing to and judging the emotions of a jury. However, the tasks more closely linked to information processing or the interpretation of documents do have a high potential for automation, which has led to a significant amount of investment by the legal world into AI technology.

[67] JP Morgan COIN software scans and interprets contracts in commercial loan-agreements. It does in a few seconds what usually takes lawyers 360,000 hours.
[68] Here it is worth mentioning that at some point the debate will intensify on whether the owners of the robots should account for them, taking legal responsibility.
[69] A platform on which over 60 million disputes are settled every year, resolved using their 'e-mediation' platform.

2.5. Health Sector

The analysis and processing of complex and large medical data also make this sector one of the most affected by the introduction of AI, the IoT and Blockchain.

The IoT, especially the 'Internet of Me', will provide constant access to an abundance of data, with wearables such as the Apple Watch, or a T-shirt that can read a patient's heart rate and prevent a heart attack. Other devices that are being developed track the state of diabetic patients by measuring blood-sugar levels and, depending on the levels, either provides recommendations such as 'drink two glasses of water', 'walk one kilometre', or puts the patient in contact with a medical centre if it detects a serious disorder. The Blockchain and AI will help in the processing and analysing of this data; providing hospitals with the ability of accessing these decentralised bases, and reading your 'chain' (medical history) instantly, giving them vital information on your health and condition, from blood-pressure risk to allergies. AI will further be instrumental in helping prevention, research and treatment, helping with early diagnosis and providing doctors with vital information. As we have discussed, the introduction of the autonomous vehicle could lead to a significant reduction of medical expenses due to the likely lower number of accidents, which would cause a reduction in the sector, although not very dramatic, since only 1.5% of the hospital activity is due to motor accidents.

Babylon Health, which currently provides online medical advice as well as real time consultations via video/phone, is developing its application, integrating AI and vast amounts of medical data to create a platform for medical assistance. Its team of 100 AI researchers is not limiting itself to creating a disease lexicon: it is trying to create the largest source of medical knowledge in the world; a virtual doctor who can identify, diagnose and even treat over the phone. The company hopes the new version of the application will become the first clinically certified robot by the Medicines and Healthcare Products Regulatory Agency of the United Kingdom to provide medical diagnostics. Babylon's diagnoses are based on a large pool of data collected from the thousands of consultations made every day since its launch, infinitely more than the number of consultations performed by human doctors annually; the company claims that these diagnoses are 92% accurate.

One of the most technological 'things' in the house of the future will be toilets. An idea for 'smart-toilets' that can collect urine samples automatically, testing for any anomalies is also under development. Steve Jobs, whose cancer was recognised too late, could have been able to access treatment much earlier, greatly increasing his chances at life. Moreover, serious strides are being taken towards the diagnosing of early stages of cancer and genetic disorders through ingestible nanobots that can detect tumorous cells and take immediate action against them.

It is also expected that in the coming years there will be notable advances in longevity, with research into oxidation and how to optimise it under way. A company was founded by Google in 2013, Calico, with the sole goal of combating aging and associated diseases, despite no cure for aging being forecast, means by which humans may extend healthy living are under development. With these advances, it may soon no longer be science fiction thinking to believe in the control of aging. Humans and chimpanzees differ by only 1% on a chromosome level, however the difference in life expectancy is huge. Through scientific development and research into DNA and oxidation, scientists may be able to enable longer life, and perhaps one day, near immortality.

Another great challenge for biotechnology is research into memory and dreams, which, alongside the universe, is considered one of the great enigmas of science. Progress is being made into the potential recording and reproducing of dreams through neural scanning, imaging techniques and advanced software. Although the potential impacts of this breakthrough are uncertain it is sure to bring about some interesting developments.

In 2016, the US Food and Drug Administration approved 36 health related applications and devices that provide medical advice to consumers, ranging from mobile lung monitors to blood glucose testing. The gradual transformation of a smartphone into a doctor will cause a tremendous shift in the health system as we know it. According to Keith McNeil, the Chief Clinical Information Officer of the NHS, within five years, smartphones –or any device we use to access information– will alleviate the workload of the limited number of accessible human specialists as well as the public cost associated with their lesser use, with automated diagnoses. Obviously, specialists will still often be needed in the treatment phase, however, a great deal of a doctor's tasks involve menial diagnosing, much of which will become automated.

A potential hindrance to the implementation these systems, is the uncertainty regarding the guaranteed protection of private information. Our health records contain some of the most sensitive details about us, from alcohol or drug abuse to sexually transmitted diseases or

abortion details – facts that are often not desirably shared with employers, friends, or even family members. This data set is permanent, and cannot be changed, such as a password or a credit card number. Thus, ensuring truly reliable security systems will be a critical variable for the success of its more widespread implementation.

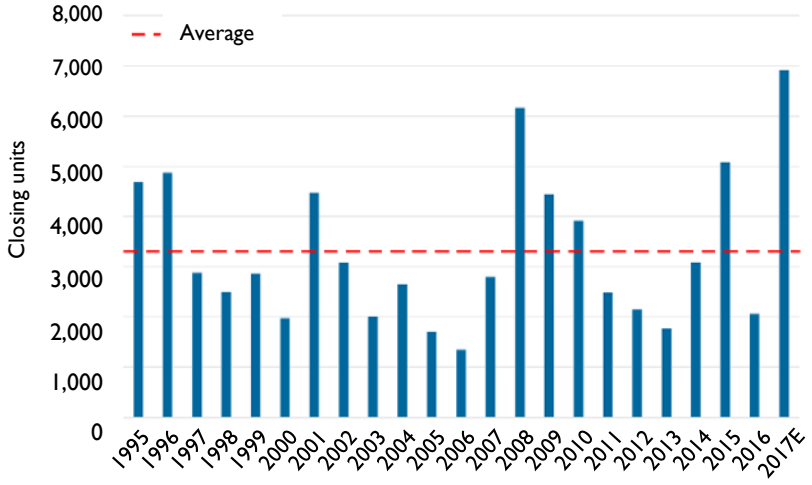
2.6. Real Estate Sector

Real estate is another sector that will be greatly disrupted by technological advances.

Autonomous vehicles may encourage a dispersing of living, further form city centres, with faster moving motorways and new public transport links. The greater comfort and reduced role for the driver will enable focus on another task – permitting work to be done for example. Moreover, the idea of circulating shared cars may free up parking space in cities, an area sure to be snatched up by developers.

The evolution of e-commerce is already inciting the closure of commercial premises, and this trend will only increase. In the future, local flagship stores may be the norm, as Apple is doing, in big city centres, and more and more sales will be conducted electronically. In the US and Pacific Asia, consumption over the internet is ever increasing, accounting for 20% and 38% of total consumption respectively, a process that is causing a significant impact in the retail real estate sector, and that is despite the fact that there is no recession, as shown in the following chart:

Figure 16. Closures of retail shops in the US



Source: Kleiner Perkins (May 2017). 'Internet Trends 2017'

The development of e-commerce, despite reducing the number of stores, will require more logistic hubs for the storage and delivery of goods to clients.

Blockchain technology will also have an impact on the business model of the industry. When all properties in the world have been recorded in the decentralised Blockchain network, we will have a historic register showing previous owners or renters, as well as purchase and lease prices. The rental market will dispose of the use of third parties such as Airbnb or rental agencies, with an easier, more direct supply and demand model, facilitated by the openly accessible ledgers presenting past pricing. The real estate Blockchain will also allow direct, instantaneous and safe transactions through the so-called smart contracts, promoting efficiency and cutting out the intermediary bureaucracy and costs. Currently, real estate websites provide some degree of transparency, both in primary and tertiary (offices as well as retail and industrial units) properties. Blockchain will shake up real estate platforms and marketplaces.[70] It will allow

[70] Internet platforms that bring buyers and sellers into direct contact.

the checking of properties and people at no cost and with absolute transparency showing information about owners and renters, as mentioned above, or lease expiration dates.

The Swedish government is currently experimenting with real estate transaction records utilising this technology, and should they succeed in establishing a more appealing norm, the trend will be sure to spread throughout Europe. Brazil, Ukraine and Georgia, among others, are also testing this method. Dubai has pledged to run all of its government services and transactions data on Blockchain by 2020, to promote efficiency and transparency.

The IoT will have an important impact on preventive maintenance in the real estate sector. Traditionally, maintenance has been a very expensive aspect of real estate, however, with the IoT technology intelligent sensors connected to a network can be installed that can analyse the state of your assets, providing the ability to better monitor deterioration and predict catastrophes. Not only will the IoT help with the physical upkeep of buildings, but it will also enable better monitoring of supplies use, reducing energy waste through lighting and heating/cooling, helping to reduce energy bills and overall consumption. Moreover, the safety of buildings and at building sites will also be largely enhanced and its costs, reduced. Smartphones and related apps will allow building owners to have access to valuable information such as how renters use the premises, for how long they are at their jobs or meeting rooms, etc.

The role of real estate agents may be further undercut by advancements and greater implementation of virtual reality, through which prospective buyers will be able to fully immerse themselves in a virtual tour of the property from the comfort of their sofa, potentially with the ability of viewing prospective changes they may wish to make, giving a great insight into their potential future home. However, virtual tours are unlikely to completely replace the physical act of viewing a house, which would incorporate getting a true feel of the building.

3D printing is expected to greatly disrupt the construction industry, with manufacturing of tools and building parts being simplified; reducing labour and supply costs. The San Francisco-based housing start-up Apis Cor recently built an entire house using 3D printing for a little over 10,000 dollars and, astonishingly, in under 24 hours. With technological advancements, housing prices are expected to drop, providing a great prospect for affordable housing.[71]

2.7. Automobile Sector

As discussed, it is undeniable that the **automobile sector** will be revolutionised as companies strive to optimise autonomous and electric vehicles. Car production will observe a significant cut in costs, with a shorter production time and fewer parts necessary for electric cars compared to traditional petrol cars. With average car use of under an hour a day, the idea of establishing a collaborative economy system with shared vehicles is likely to be popular. This would greatly improve efficiency and provide cheaper transport solutions to many, whilst potentially reducing the demand for cars, as fewer people may own their own vehicles. The US has already seen a noticeable drop in car sales, despite growing consumption, as taxi use (predominantly Uber) has risen. Apart from the significant implications on the sector, we wonder whether it will also have a social impact, with this being such a labour-intensive industry. Moreover, the development of Hyperloop, a tube-based transportation system for passengers and cargo travelling at 1,200 km. per hour, may be a major breakthrough and it is already being tested in the US and plans for its installation between Dubai and Abu Dhabi are under way.[72]

2.8. Leisure, Defence and Audit Sectors

Media and leisure sector: as discussed, press articles on some specific topics can be written by robots. AP, for example, automated the writing of reports about company results, which increased its productivity by 15 times. Meanwhile, advertising is focusing on online data giants. At present, the valuation of companies such as Facebook or Google is 20 times higher than that of the largest American broadcasting network, CBS, showing the disruptive effect on advertising-dependent sectors. On the other hand, the popularisation of the autonomous vehicle and the

[71] Apis Cor builds a house using a 3D printer in less than 24 hours: https://www.youtube.com/watch?v=GUdnrtnjT5Q
[72] https://www.youtube.com/watch?v=O_FyOBCVGWE

improvement of productivity may allow us to work fewer hours. Almost one hundred years ago Keynes predicted that by the dawn of the 21st Century the average working week would consist of only fifteen hours, although his estimation was some way off, progress does seem to be being made in that direction, as seen in Figure 7 in the Introduction. This reduction in working hours, as well as a reduction in time spent travelling will lead to a growth in leisure time, thus benefitting the media and leisure industries. Estimates suggest that weekly driving time may be reduced by 6-7 hours, releasing millions of hours of time for other activities. Large companies such as Netflix, HBO and Disney are striving to dominate the internet's replacement of television as an entertainment platform.

The defence sector's focus has greatly been on AI in its efforts in cyberwarfare; however, vehicular automation will also be important, with trucks being able to transport supplies and goods to troops in combat zones, without fear of risk of life en route. IRobot, the manufacturer of the vacuum-cleaner Rumba robot, has also developed PackBot a small portable robot that can be sent to battlefields to scout areas of potential danger, assess sites of destruction and the handling of IEDs. The US Marine Corps used 4,000 PackBots in Afghanistan and the French military is also using them. Finally, numerous air forces and intelligence services have been using drones for a long time now.

Figure 17. Military assistance and defence PackBot robot

Source: Google

Regarding the **audit sector,** junior auditors are often given tedious, repetitive, time-consuming jobs such as checking vast inventories with pen and paper. Processes such as these are costly and inefficient; thus, the large accountancy firms are all greatly investing in the development of and research into new technologies, an example of which is PwC's Halo system. Drones, with image recognition are already being used to check inventory, with AI logging and assessing the data, identifying patterns and anomalies, and providing much more accurate information on inventories. However, Blockchain will be the serious threat to jobs, since it will record all transactions, automating the entire production and sales process; that is, only if all stakeholders employ this technology, enabling full automation. The combination of AI and data will combine to allow the running of predictive and retrospective models to spot inconsistencies in financial statements.

3. The social and economic impacts of disruptive technology

Recently, the press revealed how in Japan, which seemed set to start recovering from its situation of chronic deflation, a price war has emerged following Amazon's strengthened position in the market, the intense competition between retailers, online and offline, has further fed the deflation, holding off any recovery. This is a clear example of how technological disruption can directly affect economic variables very relevant to monetary policy.

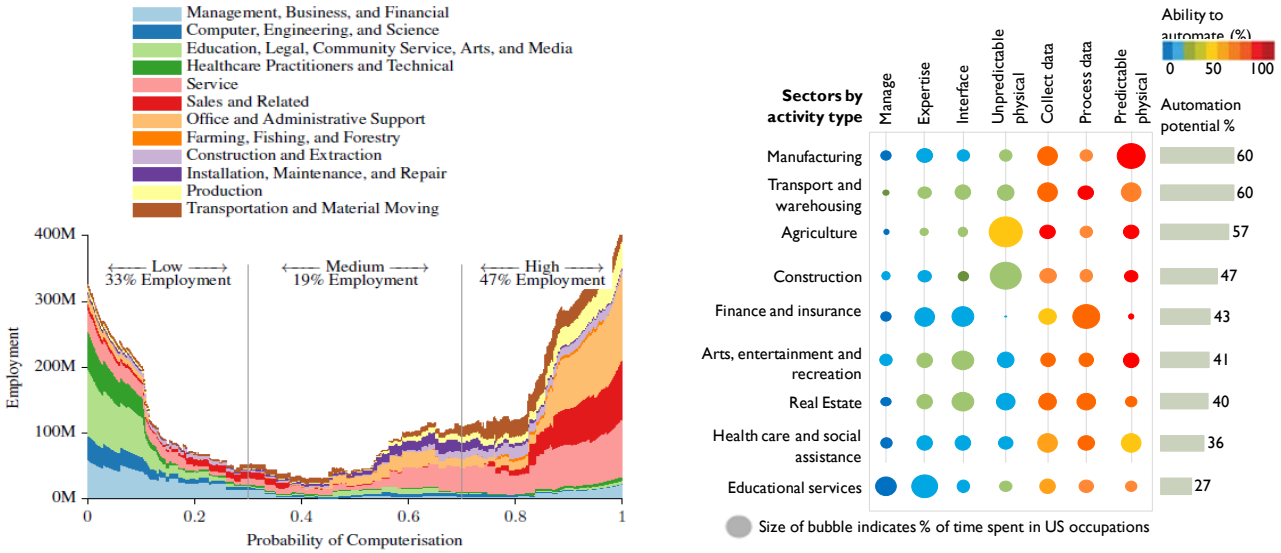
There are perhaps four main aspects of technological disruption to the economy and society: the disappearance of jobs (and creation of new jobs), productivity growth, the impact on education and the impact on inequality. We will explore each of these.

3.1. The disappearance of jobs

Quoting Voltaire, 'Work keeps at bay three great evils: boredom, vice and need'. As we have already discussed, today, truck driving is one of the most common professions among men in the USA, numbering over three million. As discussed earlier, the emergence of autonomous vehicles is sure to greatly disrupt this sector. Significant steps have already been taken in introducing semi-autonomous trucks for long-haul journeys, helping to promote efficiency and reducing employer fees, whilst potentially putting many, but certainly not all, truck drivers out of office. Full automation would create a full out redundancy in this aspect, but the time scale is slightly longer. Unlike the transition gas stations underwent where many workers were able to transition to a role as attendants, it is hard to understand what the millions of truck drivers may move on to. We are not facing a new challenge, though, in 1900, some 40% of American workers were employed in agriculture vs. 2% at present. However, unemployment rates as of today (2017) are at all-time lows. All in all, only 5% of the population are working in the technological sector, which accounts for some 10% of GDP.

The professions that have the most to fear due to automation are those in which repetitive and predictable tasks represent more than 70% of the working day, both in manual labour and in the office (Figure 18). In fact, technological advances are behind the loss of 5.6 million jobs in the US manufacturing sector since the beginning of the century, contributing to the appearance of populist movements.

Figure 18. Probability of jobs getting automated by sector



Source: Carl Benedikt Frey y Michael A. Osborne (2013). 'The Future of Employment: How Susceptible Are Jobs to Computerisation?'

Source: McKinsey (2017). 'A Future that Works: Automation, Employment and Productivity'

The percentage of the number of positions at risk is greatly disputed, with more aggressive predictors suggesting up to 47% of employees' roles are under threat,[73] whilst more conservative estimates (OECD) place the percentage closer to 9%. In either case, it is agreed that millions will be displaced, with those with lower levels of education in more danger (according to some conservative estimates one fifth of those jobs are at risk); a potentially socially dangerous fact. MIT analysed the impact that the emergence of goods manufactured in Chinese factories had on small workshops in South East Asia, which resulted in the loss of 15% of jobs in other countries. The rate of temporary jobs, poverty, suicides and alcoholism rose, as seen in some areas of the US, where a great deal of industrial jobs have disappeared.

On the other hand, given that about 30% of the tasks performed in an average job may be automated, we should talk not only about disappearance and creation of jobs, but also about transformation. Jobs will be different and, arguably, more fun and interesting. This will be a gradual process and we must be prepared to adapt to the pace of changes.

While technology is partly responsible for the stagnation of middle-class wages, whose bargaining power declines as employees improve and invest in the technology that could replace them, it has caused greater harm among the less skilled labour population, with their labour tasks often more easily mechanised and automated. Despite this, automation has undoubtedly improved overall quality of life; helping to raise literacy rates and life expectancy, whilst reducing crime rates. As Matt Ridley points out in his book, 'The Rational Optimist', in 1900 the average American spent 76% of his income on food, clothing and housing (basic spending), a statistic that has more than halved, to under 37%. Buying a Model T car in 1908 required 4,700 hours of labour for the average worker, while today one can buy a car a thousand times better by working over 70% less; 1,400 hours.

However, the unstoppable technological progress will directly be accompanied by the creation of new jobs, in areas such as the development and supervision of AI. In fact, the CEA[74] has identified four categories of jobs that could experience direct growth driven by AI in the future:

- Those involving human involvement with existing AI
- Those that develop AI technology
- Those that monitor AI technology
- Those that facilitate social changes that will accompany the new AI technology

The current limits on the manual dexterity of robots and the constraints associated with AI's generative intelligence and creativity are likely to mean that professions that require manual dexterity, creativity, intelligence and social interaction, and general knowledge will not suffer in the foreseeable future.

In addition, for centuries, the US economy has adapted and evolved with technology. Many professions that existed 150 years ago do not exist today, whilst other, which no one could have imagined then, have replaced them. As we have mentioned, today, thanks largely to technological change, agriculture employs less than 2 percent of American workers, compared with about 40 percent in 1900 or over 60 percent in 1840 (Figure 4 in the Introduction), and yet, US food production outpaces domestic demand. In this case, technological innovations, from the McCormick harvesters to the current autonomous tractors, increased the productivity of the agricultural sector and contributed to raising the standard of living. The industrial sector accounted for 25% of employment in 1950 compared to less than 10% today (see Figure 4). Anyhow, analysing unemployment statistics is not enough. We must have a look at people who have quit because their job search has been fruitless and disheartening, at those who are working in jobs they do not like, or who are working part-time but want a full-time job.

The two main questions we must address are: a) will the creation of new jobs be proportional to the destruction of old ones? and b) will the rate of destruction be the same as the rate of creation? Our impression is that the answer to the first question will be 'yes'. We base this on

[73] Carl Benedikt Frey and Michael A. Osborne (2013). "The Future of Employment: How Susceptible are Jobs to Computerisation?".
[74] White House Council of Economic Advisers.

the fact that even though e-commerce is prompting the closure of a large number of stores in the US, on aggregate, 400,000 new e-commerce posts have been created and 200,000 store jobs have been lost. As for the second question, we believe that the answer will be 'no', so we will have to face technological unemployment for some time, as anticipated by Keynes. Moreover, e-commerce needs only one employee to generate one million dollars in sales, whereas traditional retail distribution (stores and supermarkets) need from 5 to 10 employees. Therefore, the worst may be yet to come. Since millions of new jobs will be created in areas such as IoT safety, programming (which should be a compulsory subject at schools), robot supervisors etc. education is key.

The uncertainties posed by the so-called technological unemployment have triggered a discussion about the potential implementation of measures to alleviate the risks for large swaths of the population, such as a universal basic income, that is a periodic cash payment unconditionally delivered to all on an individual basis, without any work requirements.

According to its supporters, its advantages are as follows: i) avoid that a large share of people have to live temporarily below the poverty line (with the subsequent social risk and growing populism); ii) fight social inequalities derived from technological progress, with a significant part of the population benefiting from such progress, creating social justice (in fact, the potential savings for public administrations thanks to technology, such as those generated by the smaller number of accidents associated with autonomous vehicles, could be used to finance basic income or other aid mechanisms); iii) enhance creativity and entrepreneurship as a result of lower stress levels experienced by those who are receiving the basic income; iv) increase employee's bargaining power (potential salary rise which will boost, in turn, consumption and economic growth); v) reduce bureaucracy at Public Administrations; and vi) reduce debt levels of those who are receiving a recurrent revenue, which would result in lower financial risks and increased economic sustainability.

On the downside, it is argued that: i) new jobs are already appearing in developed economies and it is still unknown whether jobs destroyed will outnumber jobs created; ii) it has a huge cost (there is not a clear consensus about how it would be financed; the OECD conducted a study in March 2017 arguing that transforming the current system of direct social benefit into a universal basic income would not reach the poverty line; in the US, Martin Feldstein considers that financing a decent income is not feasible, and has stated that it would be necessary to double income tax to ensure that every individual receives some 10,000 dollars per year; iii) it will discourage job search and productivity effort; iv) there could also be a social divide provoked by an excessive duality in terms of incomes and wealth between those adapted to technological change and those who do not, v) it could boost inflation, since employees could have more bargaining power than advisable; vi) it would reduce the number of people willing to perform unpleasant jobs, since they would be receiving a basic income anyway; and vii) many people are excessively indebted at present and the rather low basic income they would receive could not be enough for debt servicing. Therefore, the rate of NPLs could increase significantly and have a negative impact on banking solvency.

3.2. Productivity

One of the great economic dilemmas of today is why, despite the technological revolution of the last decade, productivity growth has remained rather disappointing. The importance of productivity cannot be underestimated, greater productivity enables people to earn more, work less (time) and generate greater profit and progress, making it essential to an economy. Annual product growth consistently stood at over 2% until the mid-1970s where a sharp deceleration was observed; leaving levels at under 1%. Today, productivity growth remains near stagnant at under 0.5% in many Western economies.

Economists suggest that data is skewed due to industrial polarisation between the minority, being efficient, successful companies, and the majority, being less efficient small businesses. However, a large factor in these poor growth rates is the lack of integration of these new technologies in the traditional economic sectors and insufficient efforts in that direction, with focus on quality of life and leisure services, until recently. It seems that this is something that may be about to change dramatically, with greater steps being taken towards promoting industrial and professional efficiency in industries ranging from manufacturing to law.

The calculations of both GDP and productivity are based on demand expenditure, not on the improvement of the quality of life generated or in the increase of productive capacity. For example, the collaborative economy (e.g. Uber, Airbnb) increases the supply (installed capacity) of services available to the consumer, but their use does not affect statistics linked to GDP or productivity. In the next 50 years, automation could contribute to annual productivity growth

between 1% and 2% (depending on how quickly adoption comes about), which could have monumentally beneficial implications for future economic growth. The key therefore, is not necessarily greater innovation, but rather the implementation of technology that currently exists into more industries (see Figure 1 in the Introduction).

3.3. Inequality and salaries

The most widespread thesis is that technological breakthrough favours capital over labour, potentially feeding inequality. The truth is that this statement remains to be seen. Income inequality is measured by the Gini coefficient after tax, which ranges from 0 to 1, with 0 being absolute equality and 1 being absolute inequality. In periods of crisis, unemployment rises and inequality tends to rise and vice versa. Thus, in Spain the Gini coefficient has risen from 0.3 to 0.34 between 2007 and 2016. The crisis reverted Gini coefficient levels to those that existed before the pre-crisis economic expansion; we are not living at a time of historically high inequality as is commonly thought.

Another way of assessing the level of inequality in the economy is to analyse the relationship between the weight of corporate profit and wage remuneration on GDP. This indicator, however, does show a continuous decline in the remuneration of the labour force since the beginning of the 21st Century in the United States (and thus increasing inequality). According to the Phillips Curve[75], this should not have occurred at a time when unemployment was at a low level, as this implies a greater bargaining power for employees and the consequent wage pressure (creating an inflationary setting). However, in the period prior to the crisis, unemployment was at very low levels and even so, the weight of wage remuneration on GDP continued to fall. Moreover, we have spent sufficient time observing how US unemployment is close to historical lows, and yet, inflation (which is very much affected by wage increases) does not stop accelerating nor is it consolidating the Federal Reserve's target levels of 2%. These phenomena indicate that the Philips Curve may no longer be an adequate or accurate tool, with reduced unemployment rates no longer ensuring inflation. Technology may be an important factor in creating this effect, by increasing the supply of productive factors that substitute labour, reducing pay bargaining power.

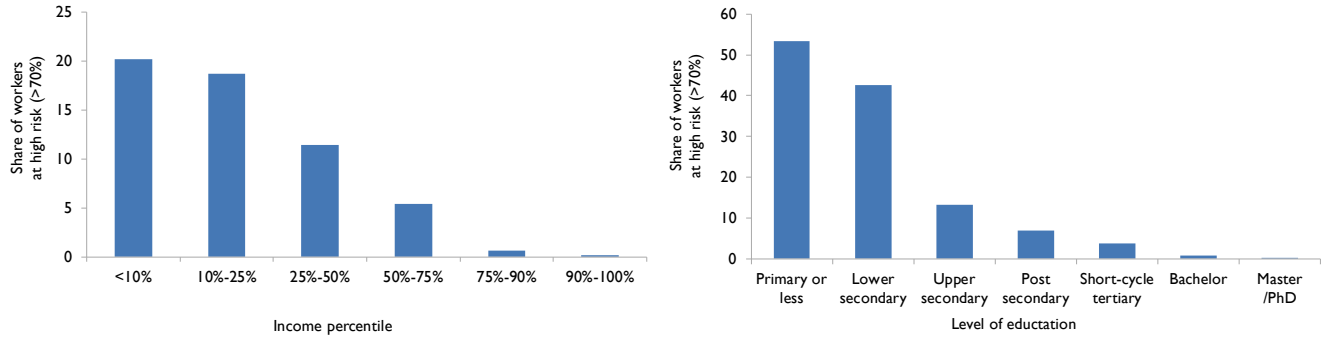
In any case, if these technological breakthroughs do bring about a surge in productivity, the associated long-term economic growth will lead to general reductions in unemployment and wage increases, thus improving Gini indicators. It is true that many jobs will disappear, but many others will appear. However, this transition may be costly in the short-term, with job loss outweighing creation, potentially instigating social tensions and broadening inequality. In order to alleviate some of this future issue it is imperative that education reforms to better prepare the population for the new technological era.

History has taught us that technology can bring about unexpected results. The 19th Century, for example, was characterised by a technological change that raised the productivity of less qualified workers with respect to those more qualified; highly skilled artisans, who controlled and executed production processes saw their livelihoods threatened by the rise of mass production technologies, with many crafts and specialised jobs ultimately being replaced by a combination of machines and low-skilled labour. Productivity (production per hour worked) increased, while inequality declined, raising the average standard of living, however, the work of some highly skilled employees lost market value.

However, the disruption brought about by this technological revolution will be greatly concentrated on labour with lower levels of education and salaries (Figure 19), potentially threatening to severely exacerbate inequality; thus, preventative, defensive policies are needed.

[75] Phillips Curve: an economic theory that describes a historical inverse relationship between rates of unemployment and corresponding rates of inflation that result within an economy (due to wage pressures associated with lower unemployment).

Figure 19. Probability of jobs at risk with respect to income and education



Source: OECD (2016). 'The Risk of Automation for Jobs in OECD Countries'

3.4. Education

The World Economic Forum (WEF) published a report in January 2016, 'The future of Jobs', regarding the type of employment that will be demanded in the coming years (Figure 20), surveying a large number of HR managers. Although the figure shows that in the 2015-2020 quinquennial many more jobs are going to be destroyed than will be created, this is due, in part, to the fact that, as yet, no estimates have been made of the evolution of the new careers that surely will emerge with the technological advance. Many of the most sought after occupational skills today, and in the years to come, are such that merely five or ten years ago, would never have been in line with the existing economy and education. It is estimated that 65% of primary school students will be working in jobs that do not currently exist.

Figure 20: Change in employment by segment, 2015-20 (thousands)

Source: World Economic Forum WFE (2016). 'The Future of Jobs'

Technological disruption, as was seen with the automation of gas stations, can also, arguably, be considered to be a factor in promoting college subscriptions. The decline in employment that did not require further education has pushed more families and individuals to pursue the acquirement of a degree. In 1970, only 14% of men and 8% of women held four-year degrees, by 2015 these ratios had risen to 32% for both sexes. Although certainly many other factors were present in developing this rise, it is undeniable that job automation played a role, helping to promote intellectual development in society.

4. Investment Implications

It is said that a venture capital investor is always thinking "what immensely profitable industries can we alter?", "how can I get a portion of a billion-dollar sector through technological disruption and thus become rich?"

A limited number of start-ups in the US have been financed by venture capital investments, so the opportunities for investors are still limited. A great deal of the technology investments in the US by venture capital funds has been directed to technology companies.[76] However, it is vital to consider the minority of investments, which are directed at non-tech companies. It is in this segment, associated with the traditional sectors, where a great deal of opportunities may arise; the application of these new technologies in these sectors will be fundamental to their growth and opportunities.

Figure 21. The 'unicorn' list'

#	Company	Location	Activity	#	Company	Location	Activity
#1	Uber	San Francisco, California	Transportaion services	#26	Social Finance (aka SoFi)	San Francisco, California	Financial services
#2	Xiaomi	Beijing, China	Consumer Electronics	#27	Vice Media	New York, NY	Media & Entertainment
#3	Airbnb	San Francisco, California	Lodging services	#28	Tanium	Emeryville, California	Business software
#4	Palantir	Palo Alto, California	Data analytics software	#29	Ucar (dba Shenzhou Zuche)	Beijing, China	Transportation
#5	Didi Kuaidi	Beijing, China	Transportation services	#30	Credit Karma	San Francisco, California	Financial software
#6	Snapchat	Venice, California	Social media	#31	Global Fashion Group	London, UK	E-commerce
#7	China Internet Plus	Beijing, China	Internet services	#32	Jawbone (dba AliphCom)	San Francisco, California	Consumer Electronics
#8	Flipkart	Bangalore, India	E-commerce	#33	Meizu	Zhuhai, China	Consumer Electronics
#9	SpaceX	Hawthorne, California	Aerospace	#34	CloudFlare	San Francisco, California	Web publishing
#10	Pinterest	San Francisco, California	Social media	#35	Delivery Hero	Berlin, Germany	Food Delivery
#11	Dropbox	San Francisco, California	Cloud storage	#36	Machine Zone	Palo Alto, California	Video games
#12	Lufax	Shanghai, China	Financial services	#37	Bloom Energy	Sunnyvale, California	Alternative energy
#13	WeWork	New York, NY	*Coworking*	#38	DocuSign	San Francisco, California	Business software
#14	Theranos	Palo Alto, California	Healthcare	#39	Ele.me	Shanghai, China	Food Delivery
#15	Spotify	Stockholm, Sweden	Streaming media	#40	Fanatics	Jacksonville, Fla	E-commerce
#16	DJI	Beijing, China	Robotics	#41	Legendary Entertainment	Burbank, California	Film
#17	Zhong An	Hong Kong	Insurance	#42	Moderna Therapeutics	Cambridge, Mass	Biotechnology
#18	Intarcia Therapeutics	Boston, Mass	Biotechnology	#43	Sogou	Beijing, China	Search engine
#19	Lyft	San Francisco, California	Transportation	#44	Vancl	Beijing, China	E-commerce
#20	Coupang	Seoul, South Korea	E-commerce	#45	Wish (dba ContextLogic)	San Francisco, California	E-commerce
#21	Ola (aka Olacabs; dba Ani T	Bangalore, India	Transportation	#46	HelloFresh	Berlin, Germany	Food Delivery
#22	Snapdeal	New Delhi, India	E-commerce	#47	Slack	San Francisco, California	Business software
#23	Stemcentrx	San Francisco, California	Cancer treatments	#48	Powa	London, UK	Mobile payments
#24	Stripe	San Francisco, California	Mobile payments	#49	Garena Online	Singapore	Video games
#25	Zenefits (dba YourPeople)	New York, NY	Business software	#50	InMobi	San Francisco, California	Advertising

Source: Fortune

This situation raises the potential for a 'war' between venture capital (VC) and private equity (PE) funds, with the former promoting small business disruption of the market; aiming to gain market share from the larger companies in which the PE funds are invested. However, the foundation of the companies may provide a great competitive advantage should they be conceived with technological roots, facilitating easier adoption of new tech, as opposed to large enterprises that may require a complete upheaval and restructuring. Potential for beneficial market exposure in the technological revolution greatly lies in the specialised VC funds, although some indexed funds could be valid too.[77] However, as is usual in the world of venture capital, there will always be a risk, with management being fundamental to optimising investments, and thus an adequate selection will be vital.

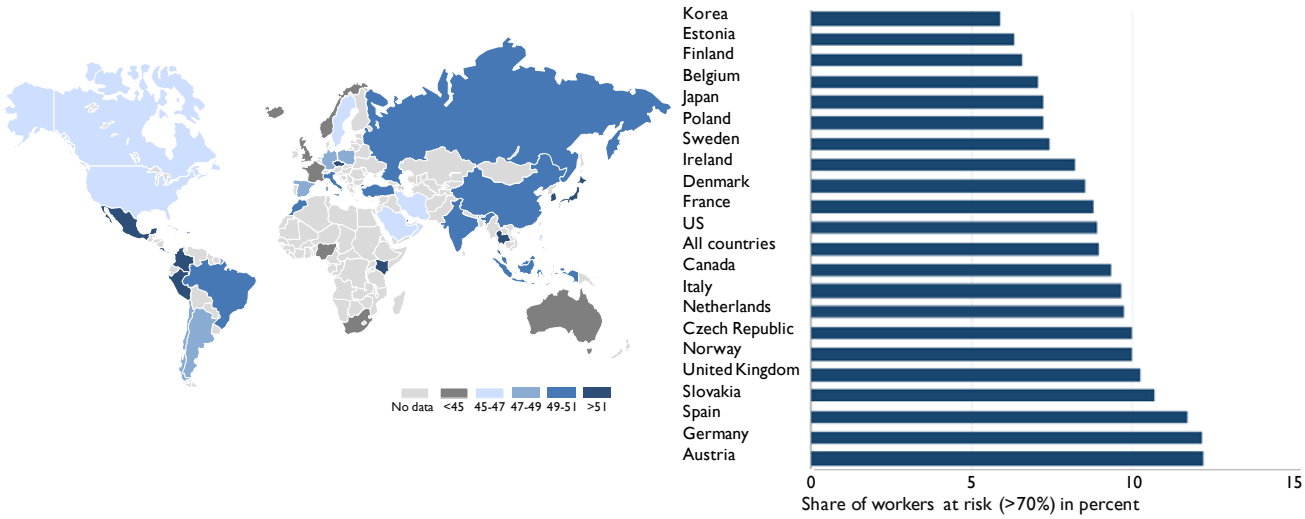
[76] According to some estimates, technology investments accounted for 17 billion, out of a total 20 billion dollars.
[77] We will write a detailed report on investment options to be published by the 'Arcano Economic Research Premium Service'.

Another key consideration is the future evolution of productivity growth which, as discussed, has been very small in spite of technological advances; however, most of the innovations have taken place in the tech sector itself, and it is now when they are starting to be applied in the more traditional ones. If the coming advancements result in substantial productivity growth the investment implications could be very profound, since the secular stagnation scenario will become outdated. The higher productivity and economic growth would lead to a rise in real interest rates (net of inflation), an outcome rarely considered by many investors (a rise in interest rates could cause financial markets to drop as a result of lower valuations of associated assets).

On the other hand, the pessimism associated with the demographic decline in terms of active workers could be rethought. In the last two years, the working population is declining in many western countries, as well as in China. In Japan, for example, which has lost over one million people a year; economic stagnation is the reality, with very meagre annual growth.

Finally, rising labour costs in China could accelerate the introduction of robots and have relevant geographical implications. A great example of this already happening is Adidas' recent move to create two new factories, one in Germany and one in the US - and not in the Philippines or Mexico. In fact, as shown in Figure 22, the countries that are set to suffer most in terms of job loss are precisely the emerging countries as a result of automation and 3D-printing advances which will make many posts redundant. Members of the OECD will not be exempt from disruption either.

Figure 22. Share of workers at high risk by country



Source: McKinsey (2017). 'A Future that Works: Automation, Employment and Productivity; OECD (2016). 'The Risk of Automation for Jobs in OECD Countries'

5. Conclusions and recommendations

A couple of noticeable things come to my mind when I recall 1997, the time when I was completing my studies and was ready to join the labour market. Before a final exam, one of my fellow economics students asked me 'what is the internet?' since she thought that this question could be included in the test. In fall that year, the Spanish police broke into the houses of a network of child abusers. That same day the news bulletin stated that 'pornographic material was found in the dwellings of the presumable pederasts, who also had access to the internet'. I could not believe my eyes. Since then, the world has changed a lot, indeed.

Many economists and bankers cannot believe their eyes either when they see that improved unemployment rates are not bringing about higher wages, as should be expected according to the classic economic law of the Phillips Curve. Perhaps the technological disruption discussed in this report helps us understand why the displacement of workers by robots is causing an excess of supply in the labour market willing to work for lower wages, resulting in a continued decline in wages as a percentage of GDP in many global economies. This phenomenon is not related to free trade since we do not have commercial relationships with Mars. We are convinced that it is a consequence of robotisation. Since basic goods prices, such as housing, keep rising well above salaries; uncertainties arise regarding the political consequences of such a scenario.

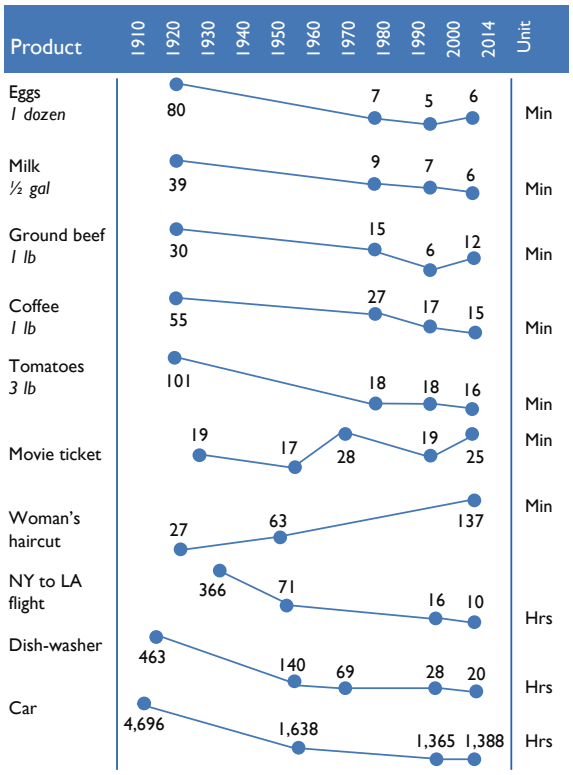
In the face of the accelerated concatenation of technological innovations surrounding us over the past few years, economists tend to experience feelings of ignorance and uncertainty that often lead to fear. Technological progression has not come about without periods of disappointment following high expectations which were not met, as well as reluctance, among segments of the population, in accepting of the proposed adoption of new technologies, often in fear of job loss.

Nonetheless, we are at a historic moment in time where the new technologies may have a dramatic impact indeed. This is thanks to significant progression in capacity in terms of capturing, storing and analysing big data, all in a very economically affordable way, combined with the enormous capacity of the existing connectivity in the networks (the internet, widespread use of smartphones etc.). With such momentous technological advances occurring in such a relatively short period of time, exponential spill-over effects are likely.

Moore's Law states that computing power doubles every 18 months, it is generally agreed that this has occurred, and seemingly, will continue; by 2020 the processing power will be similar to that of the human brain, and by 2050, if the trend continues, computers will have more processing power than all of humanity. However, many companies show a great reluctance to technological change, which could create vast disparities, with companies that embrace technology gaining a tremendous competitive advantage over those who do not.

However, the reluctance to embrace technological breakthrough by the population should be mitigated by the overwhelming evidence in favour of technological progression bringing countless benefits to the populace. Despite its uneven impact, the improvement of living standards has been mostly widespread. Illustrating this fact, Figure 23 shows that the number of hours an average worker had to work to buy a car, for example, dropped from 4,696 in 1910 to 1,388 in 2014: 70% less effort to buy a far better car.

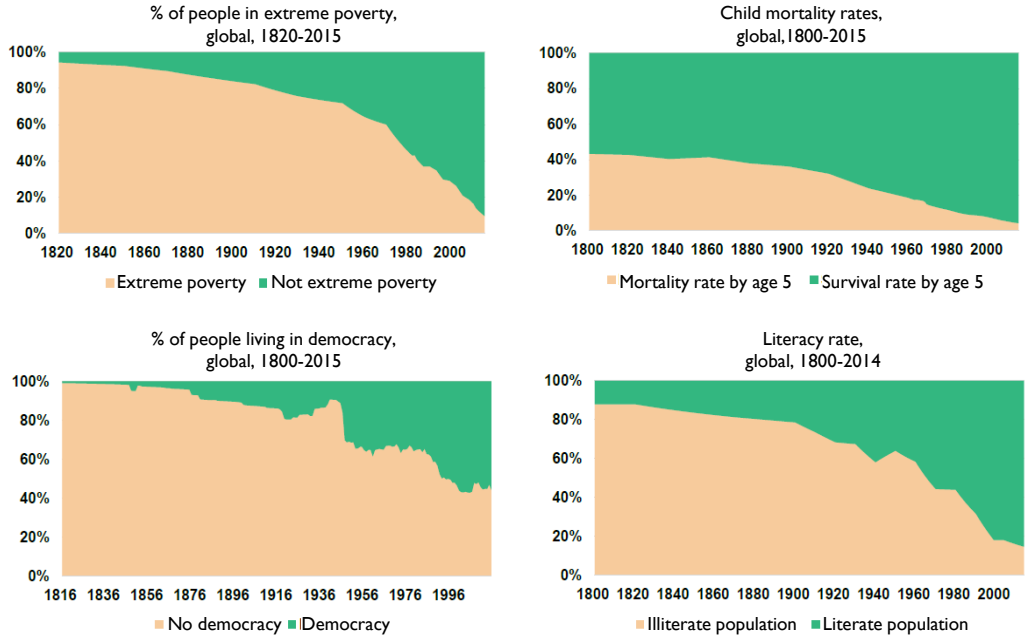
Figure 23. Number of worked hours by an average employee to buy basic goods



Source: BlackRock (2014). 'Interpreting Innovation. Impact in Productivity, Inflation and Investing'

Additionally, Figure 24 shows some indicators of the improvement of human living standards since 1800. The UN estimates that the global poverty rate has dropped by more in the latest 50 years than in the previous 500.

Figure 24. Indicators of living standards and human progress



Source: Kleiner Perkins (May 2017). 'Internet Trends 2017'

The great importance of technology in our lives is evident, as proven by some self-explanatory examples such as the fact that seven of the eight largest companies in the US, and four of the seven wealthiest men in the world, are in the tech industry. Artificial intelligence and automation, the IoT and the self-driving car are among the most remarkable advances, with widespread adoption seemingly around the corner, and potentially revolutionary impacts for the

world. Although currently still in the early stages, the power of these technologies is clearly immense, and development is quickly picking up speed throughout the industries.[78] In view of their unquestionable benefits, we believe these technologies are here to stay, although their adoption and impact time frames vary greatly, from within 5 years, to over 10, depending on the technology. Meanwhile, we will continue exposed to cybersecurity-related threats. Quoting Symantec's President "There are two types of companies, those that were cyberattacked and those that don't know yet that they were attacked."

On the other hand, we are starting to perceive some changes in the way governments are approaching technological disruption. For example, the Obama Administration had a non-interference stance, whereas the Trump Administration seems to be intent on regulating a sector which has sometimes be considered an oligopoly, since the winner takes it all. The US antitrust law, the Sherman Act, was passed in 1890, and a 1996 Act makes internet companies unaccountable for ads uploaded by third parties. However, Russia's use of Facebook to meddle in the American election is starting to change the state of affairs. There is a draft bill which would put an end to the said unaccountability and the proposal could prevent internet companies from using data collected without prior explicit consent. A similar situation is taking place in Europe, where it has been suggested that company taxation should be over revenues and not profits in order to somehow remedy the perceived meagre taxes paid by some technological giants. There are some initiatives to modify regulation on data treatment. Applications such as Facebook are not 'free';[79] data flow is estimated to amount to one trillion euros, that is, 8% of Eurozone's GDP. Facebook operating margins are close to 50%.

Given the potential disruption and progress caused by these technologies different aspects of our lives will be affected. On the one hand, in the short-term, job loss is likely, with automation replacing many professional roles, whilst on the other, new jobs will appear, as seen in previous technological revolutions; however, if the rate of job creation is too slow, creating a longer than acceptable period of unemployment for vast swathes of the population, social inequality and instability will emerge, since it is likely that lower-income professions may suffer more. Education appears to be the essential tool in mitigating this situation, with teaching and training being adapted to prepare for and capitalise on the technological revolution.

Below we list the investment implications related to technological disruption:

- With regards to microeconomics, a great deal of the technology investments by venture capital funds have been directed to technology companies. However, it is vital to consider the minority of investments, which are directed at non-tech companies, where considerable opportunities may arise. Venture capital is the best option for gaining exposure to the technological disruption, however, it is important to note the varying standards and specialisations of funds and managers, and the importance in selecting the correct ones
- As for macroeconomics, we expect future productivity rates to rise well above the current ones, which are rather limited (+0.5% in developed countries). As a result, real GDP growth rates (net of inflation) would increase, boosting in turn real interest rates, although for different reasons (see our report 'Why real interest rates will rise, triggering asset price drops'.) Investors are rarely considering these potential impacts (a rise in interest rates could cause financial markets to drop as a result of lower valuations of associated assets).
- It is important to note that the technological revolution will have an uneven impact across regions, with some countries more affected than others. Investors should consider that, for example, emerging countries may see their principal competitive advantage of cheap labour costs noticeably trimmed, due to the combined effects of increasing salary growth and the continued developments in robotics.

Finally, as it is said 'the most important thing is that the most important is the most important'. Having analysed technological disruption, we must highlight the need to be responsible and

[78] Looking back, we realise the speed at which technological disruption may deeply change our society. This is illustrated by the pictures of New York's Fifth Avenue in 1900 and in 1913. The former shows a horse and cart traffic jam; the latter, depicts a similar scene, but populated by cars rather than horses and carts.

[79] In fact, the EU has fined Google a record 2.4 billion euros for favouring its comparison shopping service in its search result pages.

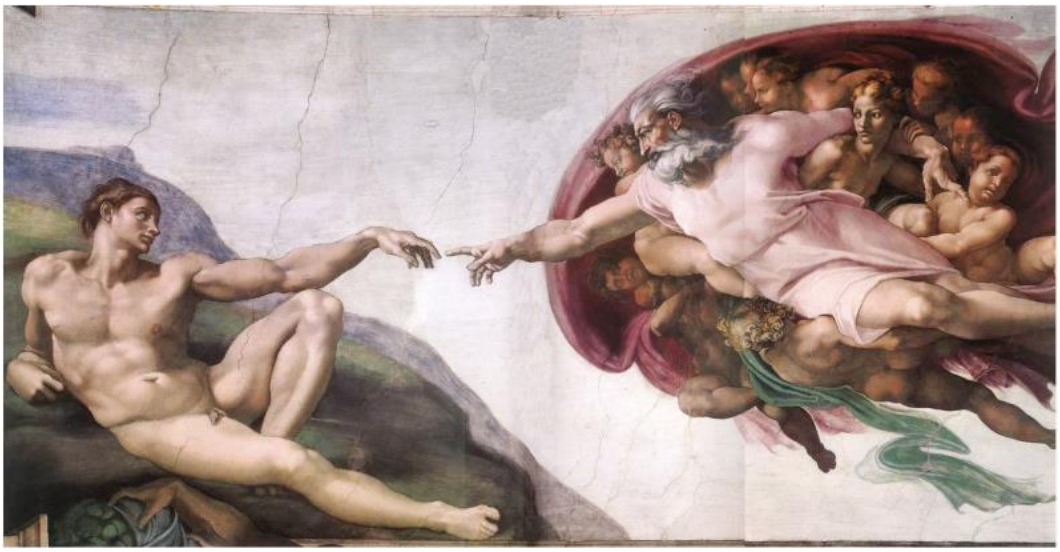
solidary in order to mitigate the negative impact that progression may have on the most disadvantaged. The focus must be on two key ideas:

- Incentivise and promote, as far as possible, an educational system that will effectively prepare the population for this new technological era. We should ask ourselves the following questions: 'how should we educate our children? And 'how should we re-educate the elderly?'
- Faced with the likely potential of significant job losses due to new technologies and the subsequent expected increase in income inequality between the owners of technological capital and those who lose their jobs, the government must work to mitigate the possible transient social discontent. This may be a challenge; potential solutions may be the implementation of new fiscal systems and well-focused temporary subsidy schemes aimed at reducing excessive inequalities, or the introduction of a universal basic income. However, implementation of any such solutions may prove very difficult from an economic point of view. In any case, it should be mentioned that savings could be used for the public reserves generated by the technology (such as the reduction of accidents by the autonomous vehicle) to finance any type of aid

We started this report by mentioning to Einstein's remark (1931) claiming that the "technologies that were meant to serve the world's progress by liberating mankind from the slavery of labour [were] now about to overwhelm its creators".

We also referred to the genius of Leonardo Da Vinci, who already in the 16th Century envisioned robots and autonomous vehicles, something which is coming true in the 20th and 21st centuries. At that time, Michelangelo also made his own mark by painting the Vatican's Sistine Chapel ceiling. In the middle of this impressive fresco, man and God's fingers are near touching. Maybe the genius of Da Vinci and Michelangelo went beyond art and is now being mirrored by technological disruption: man is playing God.

We will see what the consequences will be.



Glossary

Algorithm: Step by step procedure for solving problems, which will lead to the sought after result if followed correctly. Algorithms have a definite beginning and end, and a finite number of steps. Applied to AI, algorithms teach computers to 'think' by themselves

Artificial Intelligence (AI): The theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages. By means of algorithms, specific software tries to replicate the functioning of the human brain. An AI-based device perceives its environment, processes the information and derives conclusions to obtain new conclusions that have not been previously programmed.

Beacon: Small Bluetooth-based devices that repeatedly transmit a single signal that other devices (such as smartphones) can see once they are in range. The beacon emits a radio signal that can be picked up by nearby mobile devices equipped with the associated app. They allow geolocation of smartphone users in areas where GPS technology does not.

Big data: Big data is a term for data sets that are so large or complex that traditional data processing application software is inadequate to deal with them. Big data challenges include capturing data, data storage, data analysis, search, sharing, transfer, visualisation, querying, updating and information privacy.

Bitcoin: Bitcoin is a form of digital currency, created and held electronically, and not supervised by any central authority. It allows people to perform exchanges and pay for goods and services, avoiding the traditional financial and banking systems.

Blockchain: A Blockchain is a digitised, decentralised, public ledger of transactions. It uses cryptographic codes which provide additional safety, keeping anonymity and privacy. Constantly growing as 'completed' blocks (the most recent transactions) are recorded and added to it in chronological order; it allows market participants to keep track of digital currency transactions without central recordkeeping. It cannot be altered, since it is not possible to delete or rewrite previous records, which are visible to all public network participants, adding transparency.

Bot: AI-software software application that runs automated tasks over the internet. Typically, bots perform simple and repetitive tasks such as booking a restaurant, highlighting a date in the calendar or providing information to humans at a much higher rate than would be possible for a human alone.

Chatbot: A computer program that simulates human conversation, or chat, through AI. Typically, a chatbot will communicate with a real person, but applications are being developed in which two chat bots can communicate with each other. Chat bots are used in applications such as ecommerce customer service, call centres and Internet gaming.

Clustering: Task of grouping a set of objects in such a way that objects in the same group (called a cluster) are more similar (in some sense or another) to each other than to those in other groups (clusters). It is a main task of exploratory data mining, and a common technique for statistical data analysis, used in many fields, including machine learning, pattern recognition, image analysis, information retrieval, bioinformatics, data compression, and computer graphics

Cognitive computing: Technology platforms that, broadly speaking, are based on the scientific disciplines of AI and signal processing. They provide applications, robots or wearables with 'human abilities', such as learning, reasoning, listening, speaking, understanding or interpreting our needs and interactions by using natural communication methods.

Cognitive learning: Mental action or process of acquiring knowledge and understanding through thought, experience, and the senses. It encompasses processes such as knowledge, attention, memory, judgment and evaluation, reasoning and 'computation', problem solving and decision making, comprehension and production of language.

Cryptocurrency: A digital asset designed to work as a medium of exchange, which has the same uses as any traditional currency. Bitcoin is a cryptocurrency.

Datamining: Set of techniques and technologies that allow one to automatically explore large volumes of databases in order to find repetitive patterns, statistics or rules explaining the behaviour of data in a given context.

Deep Learning: An AI function that imitates the workings of the human brain in processing data and creating patterns for use in decision making. Deep learning is a subset of machine learning in Artificial Intelligence (AI) that uses artificial neural networks.

Hash: Also called a hash function, it is an algorithm that delivers alphanumeric outputs of the information it has received. The input may be text, a password or a file.

Hyperloop: SpaceX's trademark for the proposed mode of transportation of passengers and cargo in containers that travel r containers travel at high speeds through a tube that has been pumped into a near-vacuum.

Initial Coin Offering (ICO): A means to raise money used by advanced technological developers using cryptocurrencies. A main feature of investment in these types of cryptocurrencies is that they use restricted-use tokens, which are bought in exchange for funds for financing the launching of technology ventures.

Internet of Things (IoT): Process of having sensors embedded in all the objects that surround us in order to collect and exchange information that will later be analysed through an algorithm and used to program the object to have specific reactions. In short, IoT consists of rendering objects "intelligent", in order to improve efficiency and provide economic and health benefits, with a reduction in necessary human intervention.

LIDAR technology (Light Detection and Ranging): A surveying method that measures distance to a target by illuminating that target with a pulsed laser light, and measuring the reflected pulses with a sensor. Differences in laser return times and wavelengths can then be used to make digital 3D-representations of the target.

Machine learning: A subset of AI that allows software applications to learn automatically, that is, computers learn how to do something without being explicitly programmed, by identifying complex patterns in large bases of data. The basic premise of machine learning is to build algorithms that can receive input data and use statistical analysis to predict an output value within an acceptable range.

Neural Networks: Neural networks are calculation systems modelled on the biological brain, which is made of simple interconnected neurons that activate or inhibit other adjacent neurons. They are designed to simulate the functioning of the human brain in a computer. The system learns and trains itself by using huge volumes of data and rules about relations. Specific software may then tell the network how to act in response to an external input or may act autonomously. They are very useful in solving problems that are beyond conventional programming. In the first stage, the network learns simple tasks and sends the information on to the next level. The second level receive this simple information, combines it and creates more complex information that is sent on to the third level, and so on.

Platooning: The linking of two or more vehicles (usually trucks) in convoy, using connectivity technology and automated driving support systems. These vehicles automatically maintain a set, close distance between each other when they are connected for certain parts of a journey, for instance on motorways. The truck at the head of the platoon acts as the leader, with the vehicles behind reacting and adapting to changes in its movement – requiring little to no action from drivers, who can then perform other tasks such as administrative ones.

Ransomware of Things *(ROT)*: A kind of cyber-attack that involves hackers taking control of a computer system, coding the stored data and blocking access to it until a ransom is paid.

Robo-advisor: Online investment management tools that autonomously design and manage a financial portfolio of an investor, usually via capital allocation between various investment funds profiled by risks and assets. Robo-advisors study and learn the risk tolerance of each client, processing a multitude of relative valuation data, on which they build appropriate portfolios for each profile.

Smart contract: A computer protocol with a fix set of terms agreed by the parties intended to facilitate the performance of a contract.

Token or digital coin: Coin-like objects issued by a private entity, usually a Blockchain-one. Tokens have more uses than traditional currencies. Within a private network, a token may represent the rights to something, be used to pay for a job or to transfer data, as an incentive or to enhance user experience. Tokens have several layers of value, so the issuing company decides its worth.

Wearables: Set of electronic devices that can be worn on the body, either as an accessory or as part of material used in clothing. One of the major features of wearable technology is its ability to connect to the Internet, enabling data to be exchanged between a network and a device.

Bibliography

Ali, R., Barrdear, J., Clews, R., and Southgate, J. (2014) 'Innovations in Payment Technologies and the Emergence of Digital Currencies',

Arntz, M., T. Gregory and U. Zierahn (2016), 'The Risk of Automation for Jobs in OECD Countries: A Comparative Analysis', OECD Social, Employment and Migration Working Papers, No. 189, OECD Publishing, Paris. http://dx.doi.org/10.1787/5jlz9h56dvq7-en

BBVA (June 2017). 'Cuando los robots lo hacen todo y el ocio es obligatorio: No durante otros 100 años'

BlackRock (2014). 'Interpreting Innovation: Impact on Productivity, Inflation & Investing'

Boston Consulting Group (2017). 'The BIM Revolution Comes to Building Materials'

Bridges, R., (2015). 'Driverless Car Revolution: Buy mobility, not Metal'

Citi (2015). 'Disruptive Innovations III Ten More Things to Stop and Think about'

Citi (2016). 'Technology at work v2.0 The Future Is not What it Used to Be'

Columbus, L., (2015). '2015 Roundup of 3D Printing Market Forecasts and Estimates'. Forbes. Taken from https://www.forbes.com/sites/louiscolumbus/2015/03/31/2015-roundup-of-3d-printing-market-forecasts-and-estimates/#2a877ef71b30

Dale-Johnson, D,. Ph. D., Melton S,. (2016). 'Impacts of Autonomous and Driverless Cars on CRE'. Taken from http://www.naiop.org/en/Magazine/2016/Fall-2016/Business-Trends/Impacts-of-Autonomous-and-Driverless-Cars-on-CRE.aspx

DeNovo (2016). 'FinTech ReCap and Funding Review'

Despeisse, M. and Ford, S. (2015). 'The Role of Additive Manufacturing in Improving Resource Efficiency and Sustainability'

Executive Office of the President of the United States of America (2016). 'Artificial Intelligence'

EY (2016). 'Internet of Things – Human-machine Interactions that Unlock Possibilities'

Fortune Magazine (April 2017). 'Is This Tiny European Nation a Preview of Our Tech Future?' Finance Yahoo. Taken from https://finance.yahoo.com/news/tiny-european-nation-preview-tech-130803549.html

Frey, C. B. and Osborne, M., (2013). 'The Future of Employment: How Susceptible Are Jobs to Computerization?'

GMO (2017). 'The Deep Causes for Secular Stagnation and the Rise of Populism'

Goldman Sachs (2015). 'Emerging Theme Radar'

Hills, J., (2016). 'How Self-driving Cars Will Transform Real Estate' Taken from https://www.realestatebusiness.com.au/tech/11181-how-self-driving-cars-will-transform-the-real-estate-industry

JRC Technical Notes (2009). 'The Impact of Innovation on Labour Productivity Growth in European Industries: Does it Depend on Firms' Competitiveness Strategies?'

KPMG (2017). 'The Pulse of FinTech'

Lauslhati, K., Mattila, J., Seppala, T., ETLA (2017). 'Smart contracts – How will Blockchain Technology Affect Contractual Practices?'

Maney, K., (2016). 'How Artificial Intelligence and robots will radically transform the economy'. Newsweek. Taken from http://www.newsweek.com/2016/12/09/robot-economy-artificial-intelligence-jobs-happy-ending-526467.html

Maney, K., (2016). 'How Technology Will Solve the Planets Hardest Problems'. Newsweek. Taken from http://www.newsweek.com/2016/07/29/robots-solar-blockchain-driverless-cars-technology-revolution-482425.html

Mauldin, J., Mauldin Economics. (2017). 'When Robots Take All of Our Jobs, Remember the Luddites'

McKinsey & Company (2013). 'Disruptive Technologies: Advances that Will Transform Life, Business, and the Global Economy',

McKinsey & Company (2015). 'The Internet of Things: Mapping the Value behind the Hype'

McKinsey & Company (2016). 'Automotive Revolution – Perspective towards 2030'

McKinsey & Company (2017). 'A Future that Works: Automation, Employment and Productivity'

Mironov, V., Boland, T., Trusk, T., Forgacs, G., and Markwald R., (2003). 'Organ Printing: Computer-aided Jet-based 3D Tissue Engineering'

Morgan Stanley (2013). 'Autonomous Cars: Self-driving the New Auto Industry Paradigm'

Nakamoto, S., (2008). 'Bitcoin: A Peer-to-Peer Electronic Cash System'

Pew Research Center (2017). 'The Internet of Things Connectivity Binge: What Are the Implications?'

PWC (2016). 'Service Robots: the Next Big Productivity Platform'

RCLCO (2015). 'A Driverless Vehicle Roadmap for the Real Estate Practitioner –Part 2'

Santander (2015). 'The FinTech 2.0 Paper: Rebooting Financial Services'

Schubert, C., Van Lavengeld, and M. Donoso, L.A. (2013). 'Innovations in 3D Printing: A 3D Overview from Optics to Organs'.

The Boston Consulting Group (2016). 'Digital in Engineering and Construction'

The Boston Consulting Group (2017). 'A CEOs Guide to Leading Digital Transformation'

University of Maastricht (2011). 'Using Productivity Growth as an Innovation Indicator'

Ventola, C.L. (2014). 'Medical Applications for 3D Printing: Current and Projected Uses' US National Library of Medicine, National Institute of Health

Weller, Ch. (2015). 'Economic Perspectives on 3D Printing' *International Journal of Production* Economics (Elsevier), pp. 43-56

Wharton University (2017). 'Is Universal Basic Income a Good Idea?' Taken from http://knowledge.wharton.upenn.edu/article/universal-basic-income-good-idea/?utm_source=kw_newsletter&utm_medium=email&utm_campaign=2017-03-14

Wohler Associates (2017). 'Wohler Report 2017'

World Economic Forum (2016). 'The Future of Jobs – Employment, Skills and Workforce Strategy for the Fourth Industrial Revolution'

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Arcano Valores AV, S.A.U.
Ortega y Gasset, 29 4th floor
28006 Madrid
+34 91 353 21 40

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