Master Thesis in Engineering and Management

DRIVERS OF VENTURE CAPITALIST'S INVESTMENTS IN ARTIFICIAL INTELLIGENCE

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Abstract

The term artificial intelligence refers to the faculty, possessed by a non-human entity, to carry out operations emulating intellectual human capabilities. The interest in this technology began during the second half of the twentieth century but has never fully expressed its economic value. With the evolution of science and availability of high computing capabilities, large amounts of data, investors, AI scientists and AI friendly policies finally the artificial intelligence industry is revealing its economic and technological potential. Venture capitalists understood the business possibilities well in advance and started to finance a large number of start-ups; from the Crunchbase database were extracted for each year and country, the number of companies creating AI solutions that are funded by VCs or Business Angels; a regression analysis was then carried out to understand what were the main factors, divided into three big clusters: entrepreneurial, governmental and labour market, which allowed these companies to be funded.

In an age of intelligent machines,
what does it mean to be human?
Kai-Fu Lee[1]

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Chapter 1

Artificial Intelligence

In 2016, Joshua Neally was driving his Tesla Model X home from his office in the US city of Springfield, Missouri but But after pulling onto the highway, he started suffering pain in his stomach and chest. Rather than call an ambulance, the man decided to find a hospital using his car's self-driving mode instead of calling an ambulance. Around 32km down the road, the 37-year-old's Tesla arrived at the road leading to the hospital emergency department; the driver he manually steered the electric vehicle in to the car park and checked himself in to the emergency room.[2]

In 2016, the driver of a Tesla car died in Florida in May after colliding with a lorry. In a statement, Tesla said it appeared the Model S car was unable to recognize "the white side of the tractor trailer against a brightly lit sky" that had driven across the car's path. The collision led to the death of Tesla driver Joshua Brown, 40. The driver of the truck, which was pulling a trailer, was unhurt.[3]

In both cases the vehicles drove autonomously thanks to the support of Tesla Autopilot [1] autonomous driving system that uses big data, sophisticated artificial intelligence software, powerful hardware and sensors installed on the car to understand the surrounding environment and make the car move.

[1]for further informations visit: `https://www.tesla.com/autopilot?redirect=no`

1.1 Definition

Artificial intelligence generally means the faculty, possessed by any non-human entity, to perform intelligent operations, which would require a capacity of calculation, forecasting and planning, typical characteristics of purely human intelligence. The aim of this discipline is to emulate human intelligence: the intelligent performance is obtained in this way using machines that have their own mechanisms of operation, different from those of human but able to provide performance of the same quality.

Two versions of artificial intelligence can be defined: *Strong AI* and *Weak AI*. With strong AI machines think and carry out tasks autonomously, make decisions independently, like humans, and are supported by complex algorithms that help them to act in different situations. With weak AI machines do not act alone and rely heavily on human interference, all their actions are pre-programmed by humans to only solve the problem for which they were created by trying to simulate human behaviour as much as possible.
Weak AI is the most used, it transforms large amounts of data into usable information by identifying patterns and making predictions. In everyday life it is used for example in web search engines, smartphone keyboards, voice recognition devices (Siri [2] by Apple, Alexa by Amazon) and purchase suggestions in online platforms. The strong AI is a field in continuous exploration and expansion, it is a type of intelligence that can reason, have a conscience, solve a puzzle, learn and communicate but it is only the next level of AI, currently does not exist but scientists and experts are sure that it will happen before the end of the 21st century[4].

1.2 History

The idea of artificial intelligence related to computers was developed in the 20th century thanks to Alan Turing. The English mathematician and computer scientist helped during the Second World War to decode the German communications and in 1950 he published an article proposing a behavioural test known as *Turing's Test* to evaluate if a machine is as intelligent as a human [5].

The actual birth of the discipline took place in 1956, when during a conference at Dartmouth College, Hanover, USA a group of ten researchers set themselves the goal of creating a machine capable of simulating every aspect

[2]for further information visit: `https://www.apple.com/siri/`

of human learning and intelligence. During the same conference, another group of scientists already had a program capable of showing some hints of reasoning and was used in the demonstration of mathematical theorems through the use of basic principles of math known with the name "Logic Theorist". In this period neural networks were born and laid the foundations for machine learning.

The first problems and limitations arose in the late 1960s when the government of the United States of America suspended funds for research development. The first results from experiments were late to arrive, AI was not able to solve all the problems that it had proposed to solve and although researchers had available algorithms many software were not able to correctly calculate a solution. A further problem was the limitations at the base of the logic of the computers and the low computing power. This was the first period known as "AI Winter", a time span where there was a reduced funding and interest in AI. The AI's history is related to these winters, interest toward this field has been seen to be cyclically until the catalysts of all the interest, the results, were lacking. The most central idea of the ante 1960s period was that of finding heuristic devices to control the amplitude of a trial-and-error search.

However, the research continued over the years at a low pace but in 1982 AI was used for the first time in the commercial field. The American company Digital Equipment was equipped with a software able to give a hand with the configuration of the orders of the new computers, the experiment was so successful that in the following years the company was able to save up to forty million dollars per year [6]. After a period of boom in AI business, from the end of 80s a new winter has arrived and again a boom before the beginning of the new century, when the first milestone was achieved by AI: it started to be used by the technology industry thanks mostly to the start of a massive usage of computer and increased computer calculation power.

Research accompanied by hardware improvements allowed, in 1996, the artificial intelligence of the Deep Blue computer created by IBM to defeat in a chess game the reigning world champion Garry Kasparov; in the same way in 2016 the Go (Chinese board game) champion Lee Sedol, considered one of the strongest players in the world, was defeated by the AlphaGo computer developed by Google DeepMind which used software based on the use of neural networks [7]. In the first decades of 21st century large applications of big data and advances in Deep Learning tecnique drove the process of research and improvement of the most usable types of AI such as speech,

text and image recognition. The speed of progress and a wide diffusion of technological devices has given to AI a great acceleration in development so that nowadays its fields of application seem to be countless and its limits still unexplored.

1.3 Today's Success Factors

Today, intelligent systems are available in every daily activity, from air conditioning thermostats to finance. In general, several key requirements can be identified to explain the massive proliferation of artificial intelligence during the last ten years. A large merit is due to the progress made in computer technology both hardware and software field. By the side of computational capacity, today the available **Hardware** is way more faster and powerful compared to the one at the beginning of the century.

To ensure proper operation and performance, AI needs access to large amounts of reliable and instantly accessible **Data**. In service for this cause, solid state storage devices and information located in the cloud help manage the amount of data collected from each user's sensors, cameras, mobile devices and social networks. As an example of data collection, we can refer to the technology in home automation and wearable devices and to the amount of aggregated info about a user's habits and lifestyle collected by two of the most high tech companies in the world such as Amazon or Apple. Data are valuable, the type of info acquired could be diversified and concentrated into one source only or less diversified and distributed on various sources; high diversification and variance in data is the fundamental competitive advantage owned by the platform WeChat[8] operating in China, an ecosystem within a Chinese citizen could not live without and where a user accumulates information on his entire lifestyle from mobility and web searches to clothing purchases. Speaking about the causes of AI's proliferation, from the **Software** side the algorithms are now more stable than ever, optimized and well-known thus in this way could be easily applied for different purposes.

AI Scientists are increasing in number, the potentialities of the phenomenon are now understood and implementable, experts are now conducting studies on possible fields for AI applications as well as redesign from the bottom the way we see the reality; the interest about this subject is growing and public and private researches are increasing like the number of **Investors** both private and public because they sensed the possible economic return.

Accenture research shows that AI has the potential to boost rates of profitability by an average of 38% by 2035 and lead to an economic boost of US$ 14 trillion across 16 industries in 12 economies by 2035 [9].

Lastly, the other important factor is the presence of a **Government** that invests in research and development and adopts **AI friendly policies**. An example could be represented by the Italian government that has allocated, in 2020 as part of a national strategic plan, 80 million euros per year as budget of the I3A, Italian institute for artificial intelligence, in order to better coordinate different researches in AI and to become a landmark for the future country innovations[10].

1.4 Classification

For a better understanding of the AI phenomenon a detailed classification by field of use of the technology is proposed below. The classes have been identified following the sector map proposed by Venture Scanner.[3]

- *Computer Vision Platforms and Applications* create insights obtained from images stored on the computer. The software can be trained to understand images or texts through a complete customization by the user who can define the criteria to analyse and the accuracy level to be respected. An example of use is the detection of explicit content within an image, the understanding of a text or a full document, the mapping and control through images of the operating states of an offshore wind farm's turbines as done by AES, a global electricity company, supported by Google AutoML [11]. Image recognition and trained software are also used in *Video Recognition* for situations where video footage monitoring is required. The applications are widespread: from self-driving cars to skin cancer detection and security cameras control; these processes should involve a lot of manpower to assess the footage.

- *Smart Robots* are hardware and software devices that aim to help the human worker in the industrial manufacturing sector by increasing productivity in complete safety. These robots are equipped with sensors that allow to recognize the position of a human in the nearby and avoid shocks and collisions, moreover they can be controlled by gestural commands. Another field of use is quality control, where humans

[3]for further information visit: `https://www.venturescanner.com/2020/08/13/q3-2020-venture-scanner-sector-maps/`

are supported by a robot to reduce operator error in workstations where manual work cannot be replaced by a machine.

- *Gesture Control* are applications that allow users to control devices using their hands and other body parts. Humans can control devices by using glove with sensors that transform finger and hand motions into digital data or they can interact more naturally without use of support devices because of machines are equipped with computer vision able to detect and encode human motions. Gesture recognition applications can be found in cars, home automation appliances, consume electronics and healthcare.

- *Speech Recognition and Translation* is the ability of some devices to respond to spoken commands. Using a microphone, devices equipped with this technology translate voice signals into instructions; this technology is used today in translating speech into another language, spoken information from natural language are processed using an electronic calculator via a process known as *Natural Language Processing*; many of these systems require a training phase where an individual reads texts or words to be inserted into the device's vocabulary. Other uses are in home automation devices and in medical research. Some ALS (Amyotrophic Lateral Sclerosis) patients struggle to communicate due to motoneuron malfunctions, so they use speech recognition devices that trained to their way of speaking are able to "translate" and facilitate their communication [12].

- *Machine Learning* collects methodologies that use statistical methods to improve the performance of an algorithm to identify a pattern in the data. These systems are able to learn and improve their behavior after the performance of a task or action. It is important in this case to train the system with data sets, the more trained the system is, the better solutions it will find. Machine learning techniques combined with increased computing capabilities and large amounts of available data are gaining momentum. An example of the use of this technology are the self-driving cars, the risk control systems of banks, in the industry 4.0 and in everyday life in the suggestion of automatic correction[4] or predicting what you are about to type in smartphone keyboards.

- *Virtual Assistants* are an artificial intelligent system that emulate human interaction to perform tasks. Virtual assistants are used for variety

[4]for further information visit: `https://www.welcome.ai/swiftkey`

of applications across industries, the most common use is as a personal assistant or to cover the role of a customer care service. These applications are replacing traditional interactive voice response systems, smarter the assistant is and less frustrating it will be to talk with. However, machines alone cannot solve every problem and many times the assistance of a human is needed. The more popular personal assistants being installed on smart home devices or smartphones are Amazon Alexa, Apple's Siri, and Google assistant capable of a variety of actions like voice interaction, playing music, setting alarms, streaming podcasts, providing real-time information, order a pizza or control home appliances.

- *Recommendations Engine* is a tool used by developers to foresee the users' choices in a list of suggested items. These algorithms rely on information about the user collected before; this technology is usually used by web pages collecting the movements on the page by the user and using history of pages seen before in order to suggest high tailored recommendations. It is a powerful instrument used by online store such as Amazon, video streaming platforms as Netflix or YouTube and used also by targeted marketing companies for high personalized email campaigns and website advertisement banners; the use of these engines allows to boost sales revenue: in 2013, 35% of Amazon's revenue and 75% of Netflix's streaming were from recommendations [13].

- *Context Computing* is called the action to collect and analyze data about a device's surroundings. This type of intelligence turns real situations into info underlying data such as user preferences or behaviour pattern in order to achieve adaptive decision-making in consideration of personal historical choices. The main issues are the integration of data collected from different sources, e.g. smartphone, wearable devices, cameras, microphones, and the difficulty to convince end users to sacrifice privacy in exchange for a more contextually-aware user experience.

1.5 Research Output and Quality

As explained before, artificial intelligence is a field that has been studied for many years but only in recent times we have seen an increase in its applications in various situations and thanks to research that has continued to produce new outputs, the potential related to this technology seems endless. In a way to measure the increasing popularity of the topic can be used, as

metric, the proliferation of scientific articles concerning AI, that has been growing in the last years at an high rate. In figure 1.1 are displayed as a percentage of the total for each year the published AI papers in all publications between 2007-2018 including conferences, reviews and articles. The value has more than doubled from 2013 (1.37%) to 2018 (2.82%) demonstrating that the interest and attention around this technique are arising making AI to be the today's hot topic.

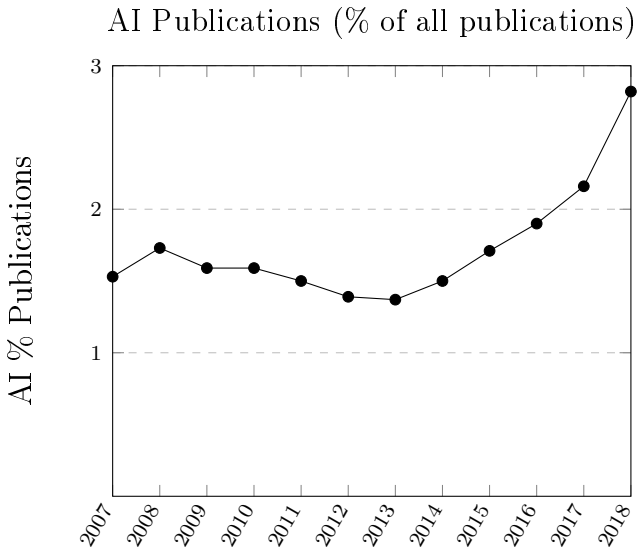

Figure 1.1: AI over total publications in the same year, (2007-2018); Scopus, 2019

However, the output of the research is enclosed in three large areas: USA, China and European Union; in total the sum of their publications accounts for about 65% of the world total each year. In figure 1.2 is shown the number of AI papers published for each year and it can be noted how in 2015 China overtook Europe, which until that moment was leading the research, by quantity of output produced. The growth pace of the Chinese country is remarkable, as in the graph, the output in 2018 is about 2.3 times that of 2015. The right answer at this point is: does an high quantity output necessary means high quality of the research?

Sometimes an high quantity of articles in output does not mean high quality papers. In order to measure the quality of the research, the instrument used is the *Field-weighted citation impact* known as FWCI and is equal to the average number of citations received by publications originating from a re-

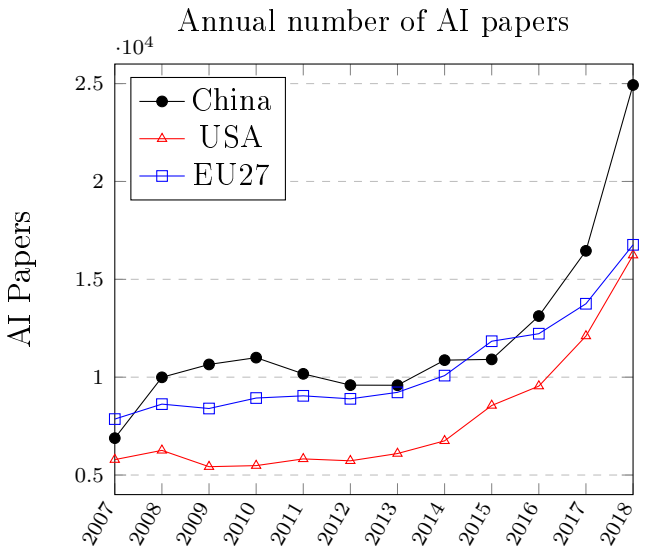

Figure 1.2: Annual number of AI paper per region, (2007-2018); Scopus, 2019

gion divided by the average number of citations by all publications worldwide in the same publication year, subject area, and document type. In figure 1.3, the citation impacts are shown relative to the world average for AI, whose FWCI is normalized at 1. A FWCI of 1 indicates that the publications have been cited on par with the world average. A FWCI of 0.85 indicates that the papers are 15% less cited than the world average. Europe's FWCI has remained relatively flat until 2015 on an average value around 1.5; China has significantly improved its output and has doubled its FWCI: in 2011 was 0.84 while 5 years later 1.61 in 2016; the remarkable performance is still in the hands of the USA that outperforms other regions in total citations with the less number of papers published: in 2016 an AI paper from USA received on average three times more citations than the global average. It is a data that confirms the undisputed leadership in research quality by the USA.

Another important element that can be noted in this chart 1.3 is the FWCI descent between 2016 and 2017 by China and the USA; one of the causes of this descent could be attributed to an increasing amount of private research carried out by private companies, which prefer to keep their advances in AI as secret in order not to lose the possible advantage acquired. The amount of private research is unfortunately not quantifiable given its nature.

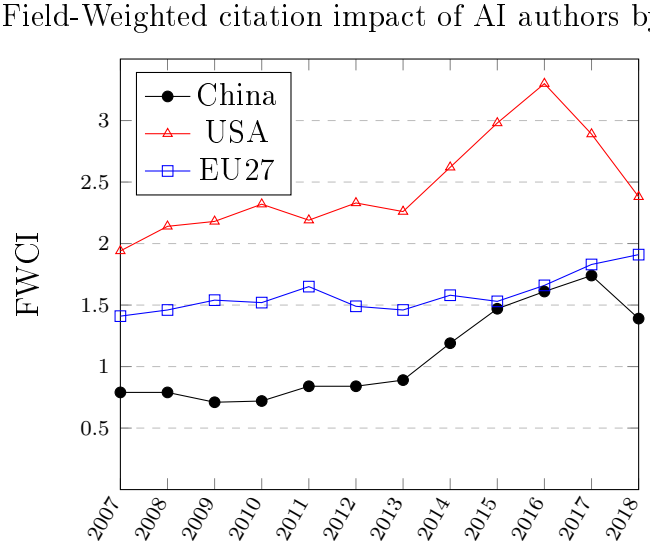

Figure 1.3: Field-Weighted citation impact of AI authors by region, (2007-2018); Elsevier, 2019

In this chapter only public researches have been taken in consideration while data about the private ones done in companies are not available. Numerical values reported in this paragraph have been taken from the *AI Index 2019 Report* redacted from Stanford University AI Index Steering Committee [14], the complete Excel database can be found at [5].

1.6 Shaping Industry Boundaries

1.6.1 Set New Standards

To understand the impact that AI might have on a firm daily profitability and activities, will be used a study done by Accenture in collaboration with Frontier Economics about the use of AI to increase profits and the level of innovation in a firm [9] for the paragraphs 1.6.1 and 1.6.2. According to this report, more than a productivity enhancer, AI should be seen as a brand-new production factor that can create a significant competitive advantage by:

- *Labor and Capital Augmentation* by creating an ecosystem where AI is aligned to society's moral and ethical values. In this way intelligent machines cooperate with humans increasing their physical speed and

[5]Database at: `https://docs.google.com/spreadsheets/d/1PPKTUAcODF5_F1gXkWK-SqPCq7BBy7Q-HGk9eBkL-NE/edit#gid=0`

mental capabilities: workers can delegate low value added tasks to AI and thus be more productive in other tasks related to reasoning, thinking or creativity; AI intelligence systems will be used from business to research, devices equipped with advanced machine learning techniques are going to support decision-making processes by creating high quality insights including important feedback and information that could have been omitted by humans.

- *Intelligent Automation* is a huge advantage over traditional automation. An important field of action can be considered supply chain management, for large companies the slightest modification of a parameter can present a great cost saving. An example is UPS that has implemented ORION [15], an intelligent system computing tons of data to optimize the routing of its fleet of vehicles: it went into operation in 2016 and allowed UPS to cut 100 million miles per year, which corresponds to more than $50 million dollars saved.

- *Innovation Diffusion* refers to the fact that AI aims to accelerate new product development processes and to reduce redundant costs due to trial and error iterations. A prominent example is the creation of a new drugs; currently the process of creating the appropriate chemical composition is based on a method of hypothesis-driven with less chance to obtain the final approval. The biotechnology company Berg[6], uses AI to map the future of disease in each patient and personalizes the drugs treatment by creating more precise diagnostics and thus reducing uncertainty ensuring the right healthcare treatment at the right time[16].

In this scenario one of the most dangerous possible obstacle to the creativity of AI could be shown by the non-recognition as inventor by the patent offices and therefore not allow the granting of the patent; as an example DABUS[7] is an artificial inventor who has seen the refusal of the granting of the patent by the United States, United Kingdom and European patent offices[17] because only natural people can be considered as inventors.

The other threat in AI implementation in companies processes can be seen in the failure of corporate data management. For machine-learning projects to succeed, businesses must be able to identify the most important data, clean and made them ready to use; in a global survey of 1500 executives

[6]for further information visit: `https://www.berghealth.com/research/`
[7]for further information visit: `http://imagination-engines.com/iei_dabus.php`

from companies with a minimum revenue of US$1 billion it results 75% of them believe they risk going out of business in five years if not implement AI, but 76% of them acknowledge they are struggling to scale AI[18]. Like any new disruptove technology that presents a complete break with the past, AI also needs time and great internal cohesion in terms of mentality and confidence in the project; it is not enough just to have the technology and the data, it also needs alignment in the mindset of all the stakeholders included in the company and perhaps this is also one of the biggest obstacles will be faced by AI perhaps in the beginning. It is precisely in this delicate period of transition that AI must be promoted and supported until it can become a model for future adopters; the best way to do this is training employees to create a culture based on AI.

1.6.2 Boosting Industry Profitability

Artificial Intelligence seems to be the catalyzer of future growth; a study, conducted on twelve developed country capable to generate together more than half of the world's economic outputs, shows AI could double the annual economic growth rate by 2035; the unit of measure used is the *gross value added* known as GVA, very close approximation of GDP, and accounts for the goods and value produced in a certain sector: can be thought of as contribution of different sectors to economic growth.

In figure 1.4 gray bars report data about the possible growth rate a country will face by 2035 under the use and development of AI, while the orange bar refer to the mean growth rate by year without implementing sounds projects about AI. Obviously not all the economic sectors will face the same growth rate or the same impact on profits rising. The most relevant between impacted industries will be:

- *Manufacturing* is heavy dependent on machinery to the extent that they are the breeding ground for developing AI solutions. Not only human will face an augmentation of their capabilities but machines will be used in a smart way in order to deploy the full potential of the existing shop floor. In cooperation with AI, manufacturing can generate an additional US$3.8 trillion in GVA by 2035.

- *Wholesale and Retail* will be able to efficiently control their stock in inventory by understanding what the customers' requests will be and improve their journey by creating an immersive shopping experience;

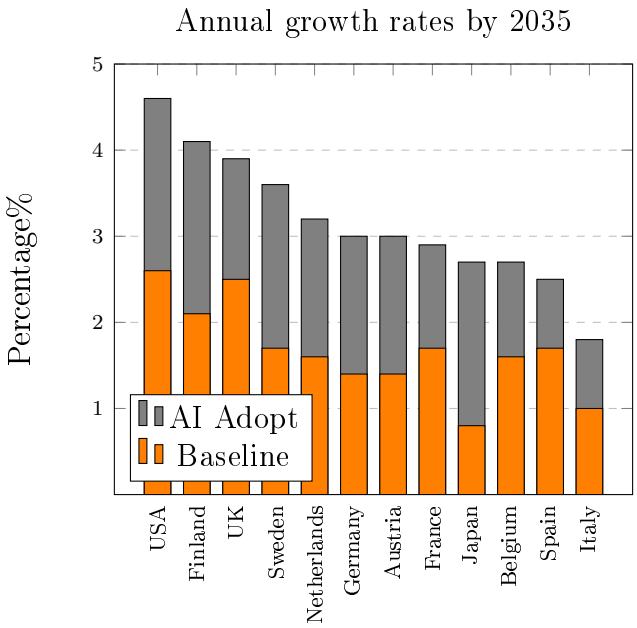

Figure 1.4: Estimated annual growth rates by 2035 of gross value added (GVA); Accenture and Frontier Economics, 2017

purchases can be made from home, there will be no need to physically test a product or try on a t-shirt, as an example L'Oréal in 2017 launched a new app called *MakeUp Genius*[19] which allows you to try the suitable cosmetic by simulating through the use of a camera how it would be applied manually. In addition, technology will be able to better understand the small and high profitable niches of the market. Estimated yield by 2035 is more than US$2 trillion.

- *Healthcare* will see a generation of US$461 billion of additional GVA. The most interested parties are imaging diagnostics, customization of medical treatments and the creation of cutting-edge 3D printing techniques for organ transplants.

Below in figure 1.5 are reported the estimations about share profit increase in 2035 between company using AI against company, in the same sector, do not use. The education industry almost doubles its output (+84%), thanks to the use of distance learning, the cost of maintaining the physical structures will be significantly reduced by allowing higher margins. By following Accommodation sector (+74%), Construction (+71%), Wholesale and Retail (+59%) and Healthcare (+55%). Those who will be able to implement and create an AI culture within their company from today, will be able to have

massive economic advantages in about ten years.

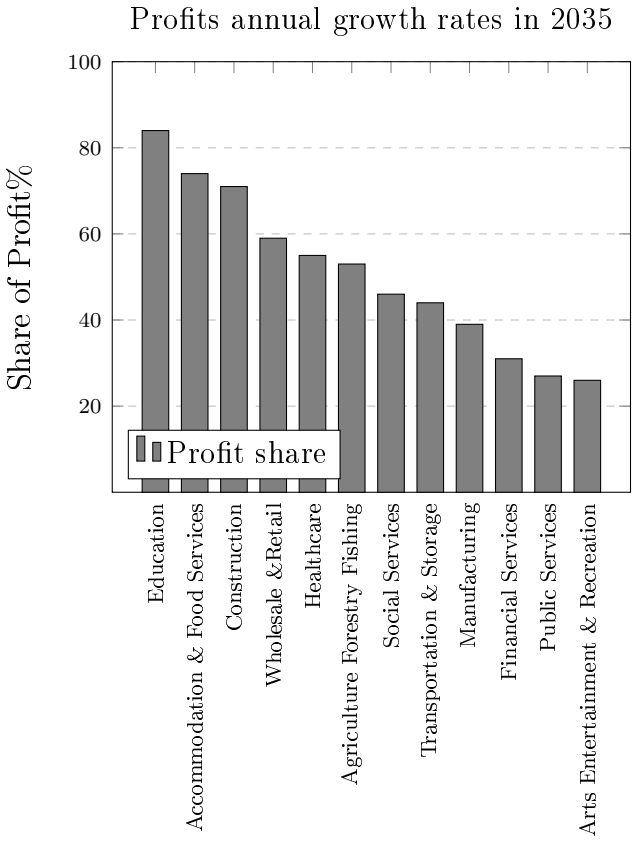

Figure 1.5: Share of profit increase per industry between baseline in 2035 and AI adopter industries in 2035; Accenture and Frontier Economics, 2017

Talking about the future and when artificial intelligence will have become an established reality is simple, but to have a complete picture of the situation it is also important to consider the current state of art. In this regard, figure 1.6 and figure 1.7 show the result of a survey conducted by McKinsey in November 2018 about the progress and adoption of AI in companies today[20]. Specifically, a survey was carried out to which 2,128 companies replied; there were 330 companies that confirmed that they had a level of digitization higher than 51% and their replies refer to figure 1.6 where only the most digitized companies were included; the remaining 1,798 companies refer to figure 1.7. From the two graphs, what stands out is that the most digitized companies have in general a higher awareness about AI and have already started to implement it in their internal processes; in this regard it

should be noted that machine learning is the most used type of AI, with about 70% of digitized companies already using it. However, it remains to be noted that in general the percentages of non-use of AI is still high but significant improvements could be achieved in the next few years.

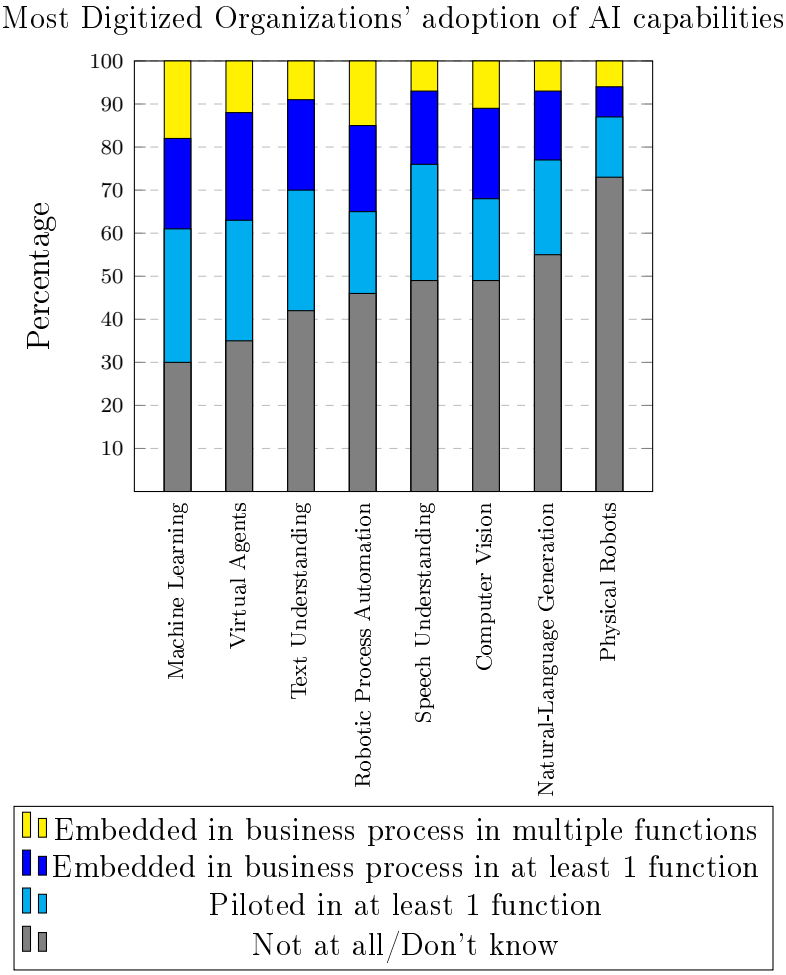

Figure 1.6: Most digitized organizations' adoption of AI capabilities, survey; McKinsey, 2018

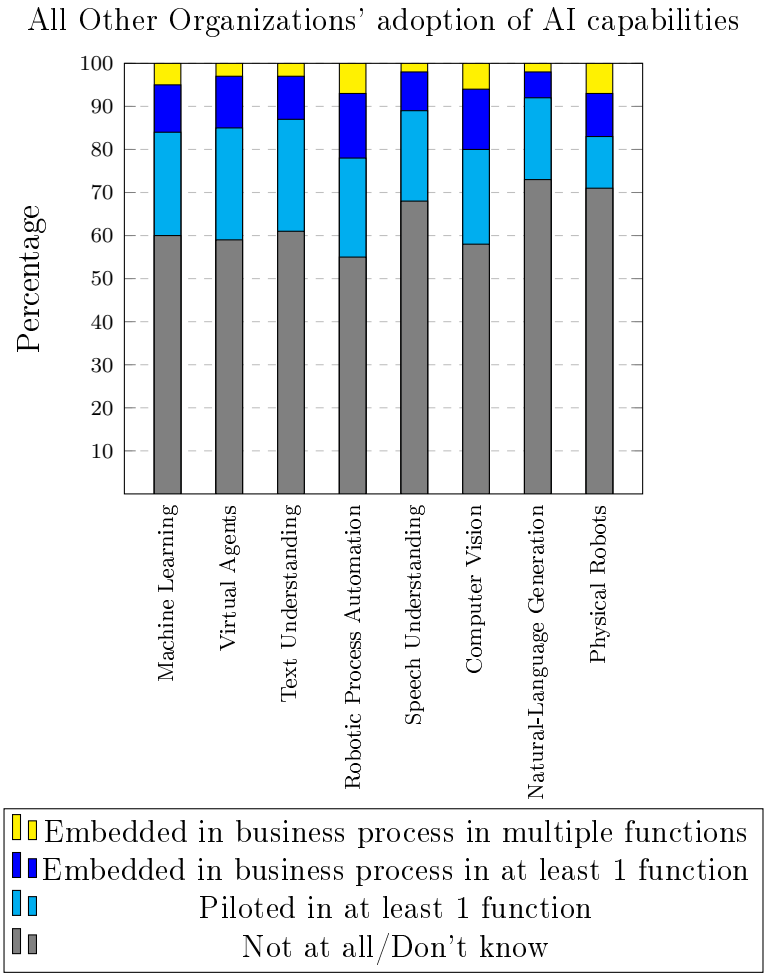

Figure 1.7: All other organizations' adoption of AI capabilities, survey; McKinsey, 2018

1.7 The Chinese Approach

1.7.1 Long Term Plans

China is nowadays, together with the United States, the most developed country in research and application of technologies using Artificial Intelligence. China's rise to success was not purely accidental, but was the result of long-term planning that began in the early 2000s. The Chinese government at the beginning of the 21st century understood the need to modernize the country in order to improve the living conditions of its citizens and to create within a few years a global superpower and leader in the use and development of technology, and in order to succeed in this goal, a number of guide lines have been set up, with several plans covering a well-defined time span with very ambitious targets to be reached.

The first signs of revolution began in 1995, when the Chinese government pledged to strengthen its nation through the use of science, technology and the use of the latest and most advanced education. In this regard, action has been taken to create a suitable territory for development: funding for research and development has been significantly increased, more students have attended higher level studies and there were set initiatives to improve intellectual property protection in order to attract investors and retain innovation.

The first real strategic move was played in 2006 when in the Chinese country began a 15-year "*Medium-to-Long Term Plan for the Development of Science and Technology*" known as MLP [21]. Work to prepare the MLP began in 2003 when more than 200 scientists, engineers and executives were involved in a strategic research program to identify the most critical problems and opportunities in twenty areas considered important by the government, including energy, environment, agriculture and development of frontier technologies. The MLP called for China to become an innovation-oriented society by 2020, and a world leader in science and technology by 2050.

According to the MLP, China should have invested 2.5% of its increasing GDP in R&D by 2020 (GDP in R&D in 2019 was 2.23%), up from 1.34% in 2005: should be noted that GDP in 2005 was US$2.28 trillion while in 2019 accounts for US$ 14.4 trillion, six times more in only fifteen years; MLP also defined to raise the contributions to economic growth from technological advance to more than 60%, and limit its dependence on imported technology to no more than 30%[22]. The plan also calls for China to become one of the top five countries in the world in the number of invention patents granted to

Chinese citizens, and for Chinese authored scientific papers to become among the world's most cited. MLP had an important impact on the trajectory of Chinese development and laid the foundations for future AI R&D by establishing the use of smart sensors, smart robots and virtual reality technologies.

In April 2012, the Ministry of Science and Technology (MOST) released the *12th Five-Year Development Plan for National Strategic Emerging Industries*. In this plan, Chinese planners have included several preferential tax, fiscal and procurement policies designed to facilitate the development of seven strategic emerging industries which were biotechnology, new energy sources, high-end equipment manufacturing, energy conservation and environmental protection, clean-energy vehicles, new materials, and next-generation IT. According to the plan, the share of value-added from these seven industries was targeted to reach roughly 8% of the country's GDP, while the expected annual growth rate of the total industrial scale was above 20%. [23] Industrial robots and the Industrial Internet of Things were listed as key technologies which, if developed, could have enhanced China's manufacturing capability; the key priority was the transition from "Made in China" to "Designed in China" [24].

In May 2015, the program *Made in China 2025* was released, in which for the first time the artificial intelligence was named and smart manufacturing was identified as an element of strategic importance to guide the future of Chinese production and it was a blueprint to upgrade the manufacturing capabilities of Chinese industries from labor-intensive workshops into a more technology-intensive powerhouse [25]. China aimed to move away from producing cheap, low-tech goods facilitated by lower labor costs and supply chain advantages. The initiative encouraged production of high tech value products and services, like aerospace, semiconductors and biotech, to help achieve independence from foreign suppliers. The plan was described as an initiative to comprehensively upgrande chinese industry and the Chinese government was committed to invest about US$300 billion to achieve this plan [26].

To well define all the different policies during the previous years will be difficult, table 1.1 summarize the ongoing initiatives in AI taken from the OECD AI Policy Observatory[8]. The list of policies is not comprehensive; it should be noted that many initiatives have been established by the gov-

[8]for further information visit: `https://oecd.ai/dashboards/policy-initiatives?conceptUris=http:%2F%2Fkim.oecd.org%2FTaxonomy%2FGeographicalAreas%23China`

ernments of each individual city, and the table does not taking count of the strategic action plans of the large Chinese multinationals that dominate the AI sector.

In May 2019, under the flourish of numerous AI projects by the government and the private sector, the necessity to give some guidelines to the research improvements was felt and the *Beijing AI Principles* were released by a pool of universities, AI scientists and AI industrial companies. The 15 Principles call for the construction of a community with shared values and the realization of beneficial AI for mankind and nature. The principles are organized in three sections: Research and Development, Use and Governance [27].

In order to have a complete overview of phenomenon, the number of companies operating in China in the development of AI in 2018 is proposed in figure1.8 organized by province. In China as in the USA with Silicon Valley, the value of the entrepreneurial and technological cluster is important; it is possible to note that there are three major poles of innovation in the country represented by the provinces of Beijing, Shanghai and Shenzen, which alone account for almost 80% of total operating companies.

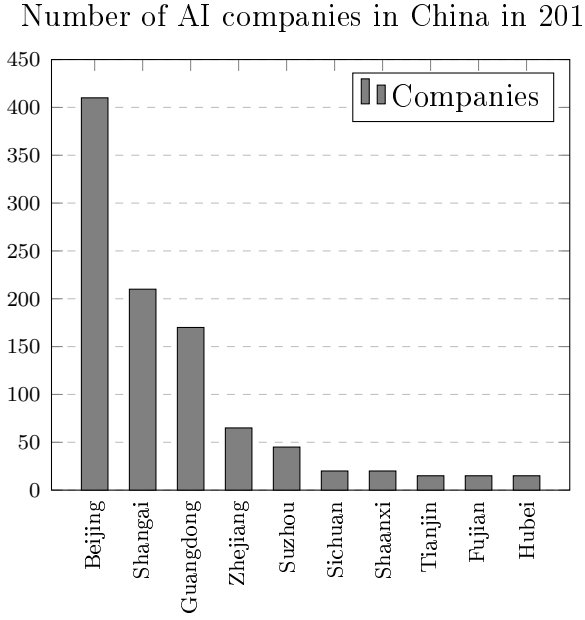

Figure 1.8: Number of AI companies in China in 2018 by province; Statista, 2020

Policy Name	Description	Start
National new generation artificial intelligence governance expert committee	The purpose is to coordinate effectively the relationship between AI development and governance, ensuring the reliability and safety of AI while promoting economic, social and ecological sustainable development	2019
Principles of next generation AI governance - Responsible AI	Highlights the theme of developing responsible AI, emphasizing eight principles to ensure AI is safe and controlled	2019
Beijing national new generation AI innovation and development pilot zone	The zone will focus on innovative systems to develop and launching AI platforms through the coordinations of government, academia and industry aiming to develop AI-related theories, talents and ideas	2019
National engineering laboratory for deep learning	Laboratory establisehd to accelerate the AI research on deep learning	2017
The next generation for AI plan	The plan involves initiatives and goals making China's AI industry in line with competitors by 2020, reach world leading in some AI fields by 2025, become primary center for AI by 2030	2017
Three year guidance for internet plus AI plan	Focus on: enhancing hardware capacity, strong platform ecosystem, AI applications in socioeconomic areas, AI's impact on society	2016
Chinese association for Artifical Intelligence	Association aims to support the research on AI	1981

Table 1.1: Chinese AI ongoing policies; OECD AI policy observatory, 2020

1.7.2 BAT: National Champions

The acronym *BAT* refers to the three largest high-tech companies in China, leaders in the development and use of AI and Big Data. BAT stands for Baidu, Alibaba, Tencent, three companies born in China that have influence and control over every action day by day, hour by hour of the entire Chinese population. Their dominion over the national territory lies in three fundamental ingredients:

- The size of China's domestic market, with access to a userbase of 1.4 billion people, BAT serve the largest consumer market in the world.
- High protection of the domestic market by the government; a striking example is the block of Facebook in 2009 and Google in 2010[9]; without the competition of foreign tech giants, Chinese companies were able to concentrate on their domestic market, which is boasted by a massive demand.
- Widespread belief that the future will be dominated by those who currently control AI, hence great incentives from the government to develop projects in AI and great enthusiasm from Chinese consumers to embrace the revolution and use of AI.

Baidu is known to be the most popular search engine in China, with a market share over 75% unrivaled in the industry; Sogou the second most used engine between the competitors has a share of 13%.[28] Baidu is more than a search engine, is a global AI innovation leader, with projects embracing very different areas; *Apollo* is a global open source platform for autonomous vehicle developed by Baidu and a consortium of more than fourty companies and, in the forthcoming future will team up with Guangzhou Public Transport Group in one of the most ambitious project in intelligent transportation ever made by using its know how to develop an intelligent transport network in the city offering fleets of autonomous taxi and bus [29]. *DuerOs* is a conversational AI platform created by Baidu that combines speech recogniton, facial recognition and natual language processing; the platform can be installed in everyday electronic devices. Baidu is also big on research with locations in Silicon Valley, Seattle and Beijing which compete with companies like Google and Amazon to attract international talents. In 2017, *Baidu Venture* was launched, an investment fund manages about US$500 million to be financed in research on artificial intelligence with offices in Beijing and

[9] A dynamic list of blocked websites in China available at: `https://en.wikipedia.org/wiki/List_of_websites_blocked_in_mainland_China`

San Francisco.[10]

Alibaba is the world's largest conglomerate of e-commerce platforms: alibaba.com B2B, Taoabo C2C, Tmall B2C and AliExpress targeting mainly European and international consumers. The userbase is huge, with 742 million active users accounted for the second quarter of 2020 [30]. Its annual event called Single day consists of 24 hours of discounted prices on the market place and in 2019 reached the record of more than US$39 billion in sales. Alibaba is also active in the cloud computing market with *Aliyun*, an alternative to cloud providers as Amazon AWS, Google Cloud and Microsoft Azure. The other major branch of the company is *Alipay*, a mobile payment platform created as a spin-off from Alibaba. It is the largest mobile payment platform on the market and will soon be listed on the Hong Kong and Shanghai stock exchanges as AntFinancial, with a market value close to US$34 billion that would allow it to set a new record for the highest IPO ever [31]. The large amount of data available on users is the real main resource for AI and deep learing; in this way Alibaba is able to fully customize the shopping experience for each user by offering specific products according to their interests.

Tencent is a large holding company with subsidiaries that provide instant communication services, online payments and video game creation. the most popular product developed by Tencent is *WeChat*[8], an application born in 2011 as the Chinese proposal to the American Whatsapp but soon ended up becoming a digital ecosystem that does not allow you to live a day without in China. Instead of creating many different applications for different services as it happens in the USA and Silicon Valley, Tencent has integrated everything in WeChat; through this application it is possible to send messages, read news, order food, organize trips, make payments and more. *WeChat Pay* is the alternative to Alipay offered by Tencent in the world of mobile payments and obviously the application is perfectly integrated in the WeChat system. Tencent is also the world's largest online gaming creator company. The company's great interest in artificial intelligence can be seen in one of its best-known slogans used during the opening of its AI lab in Shenzen in 2016: "Make AI Everywhere" [33]. At the moment, one of the priority in research and development for Tencent is the healthcare industry.

The source of these corporations' competitive advantage lies in the quantity and quality of the information they possess.

[10]for further information visit: `https://bv.ai/en/`

1.7.3 Social Credit System

One of the most controversial projects launched by the Chinese government is perhaps the *Social Credit System*. The project was launched in 2014 and is expected to be fully operational by the end of 2020; this initiative has been declared as a way of classifying the reputation of citizens and for this purpose everyone will be given a score representing their social score on the basis of information possessed by the government regarding the economic and social background of each citizen. The aim of the project is to increase the global trustworthiness of the citizens, and thus map and punish bad actions such as an employer who does not pay his employees or a citizen who does not pay his debts. It is also a way to be able to track the entire population and assign a level of credit to each citizen because not everyone has a bank account, especially in rural areas.

The idea is to convert every single action into a number that will increase or decrease the global score. The tools used will be big data analysis, artificial intelligence and a massive system of cameras installed on every corner. *Skynet* is the name associated with the mass surveillance project which has more than 200 million cameras[32] scattered all over China which, thanks to facial recognition, body tracking and Geo-tracking, recognize and keep track of every action done by a single person; In addition to these sources of information there are also government agents who are paid to keep track of citizens' actions.

The modification of the score will be based on:

- Invoices payment.
- Ability to comply with the stipulated contracts.
- Personal preferences by live monitoring position and purchases via app or physical. For example, a person who buys and consumes too much alcohol can be considered a problem for society; a mother who buys nappies can be considered as positive attitude; spending too much time on video games can be a sign of laziness and lower productivity.
- interpersonal relationships will be influential, it is not enough to be a virtuous citizen, but also the behavior of the people closest to the individual will change their score.

The ways in which points can be gained will be announced through panels in the streets, TV channels, or via internet; the TV channels at the end

of the day will broadcast the less noble acts performed by citizens, making known the identity of those who made the action. The potential risk a person may incur by lowering its score is the possibility of being placed on a blacklist or having their access to a certain type of service reduced, such as purchasing of airline and high-speed trains tickets, denied access in certain schools, exclusion from high prestige work positions, exclusion from hotels and more [34][35]. Likewise, those with a high score will receive rewards, travel discounts, easy access to credit and more. The score level can be used as a sense of belonging to a specific social status; for chinese citizens this will note be a brand-new situation, as an example *Baihe*, a dating platform has has allowed users to publish their credit level as an indication of their social status; in this case the score is referred to the *Sesame Credit* level, a credit score directly managed by AntFinancial not related to the government's social credit [36].

However, the official launch of the project has not yet taken place, only pilot projects in some areas have been launched to verify the feasibility and to evaluate the effects of the system. At the same time, ranking systems not belonging to the government are already running and widely accepted.

1.8 Other Countries

In the rest of the world, many other countries are preparing for the revolution's race; there are several ones with significant stake in AI, the most important are:

- *Japan* has always been a leader in the AI industry, especially in the development and adoption of robotics. mention should also be made of the presence of Softbank and its Vision Fund[11], an investor with almost unachievable power and reach in the venture capital industry. The Japanese government issued its strategic road-map document in March 2017[37] specifying the path to follow for the implementation of AI in three distinct phases: use and application until 2020, public use in 2020-2025, ecosystem built by connecting multiplying domains after 2030. The aim of the project is to reduce the gap between USA and China in number of AI related paper and in this direction the government will help in carrying out researches.
- *United Kingdom* has a government that understands that by 2035 AI can make a contribution of US$814 billion by increasing the annual

[11]for further information visit: `https://visionfund.com/`

growth rate of GVA from 2.5% to 3.9%[38] to the economy and is trying to create an environment favorable to the formation of new technology businesses; although the UK is not a country that plans to finance with large sums of money, it is still a leader in terms of knowledge of the subject, at least for the current time. In order to maintain its position in the market, the government has focused on education and in 2018 new degree programmes have been proposed and funded, in agreement with private companies: 2000 new PhD students will be financed over five years for a sum over US$200 million in order to continue and improve research.[39]

- *France* in 2017, led by its President Macron, began a process of approaching AI through public investment amounting to approximately US$1.85 billion over the period up to 2022.[40] The French Prime Minister has declared that he does not want to "miss the AI train" and, alongside the investments, wants to make sure that France takes ethical measures to regulate the industry so that AI will act as neutral as possible. The expected result of these measures is a greater talent retention capacity and the creation of an AI hub. In the meantime, companies such as Samsung, Fujitsu, DeepMind, IBM and Microsoft have announced that they will open their AI offices in France [41].

- *South Korea*'s government is a significant investor and a big fan of local technological development, and AI makes no exception; in 2018, plans were made to invest over US$2 billion by 2022 to increase its r&d capabilities. Six new research centers will be founded and more than 5000 new high-level engineers will be created in response to the shortage in the market. The aim is to reach the top four in the sector and to focus studies in the medical, military and public safety fields. The Ministry also announced a short-term project to address the AI talent shortage with six-month intensive training courses that will gestate 600 young talents by 2021. Meanwhile, universities are being encouraged to set up AI courses [42].

- *Germany* in 2018 adopted a national strategy on AI and made available more than US$3 billion in investments for the period 2019-2025. the objectives are multiple, including becoming a European leader and increasing the country's competitiveness, safeguarding society by promoting the ethical use of artificial intelligence and trying to integrate technology as much as possible into everyday life. Germany is one of the most powerful economies in the world, making the best use of AI and applying it in production would be extremely productive; this

is the direction in which the major German car makers and industry players are moving [43].

- *Italy* The Italian Ministry for Economic Development called in 2019 a task force of thirty selected experts to work on a national plan of proposals to create an Italian strategy on artificial intelligence [44]. The plan covers various issues such as the risks associated with the use of AI, the Italian production system and the direction that AI should take towards people and how to face future challenges with workers and job losses. The most significant aspect that emerges from the document is related to the sustainable development of AI and its integration with existing systems. Following this document, a development plan worth a total of around US$1 billion was approved in July 2019 to be invested by 2025 [45]. In 2020 was announced, the creation of the National Artificial Intelligence Center (I3A), based in the city of Turin and hosting about 600 workers in collaboration with universities and researchers.

It would be reductive to think that the technological competition is limited only to these large developing hubs (including of course, China and the USA). Actually there are interesting hotspots all over the world in countries such as Canada, Israel, Russia and all over Europe. The most important thing to underline is how the market is coming out of its first phase of growth in which a big contribution from the government is needed as the technology is not yet well developed. The sector is entering a period of growth where funding is needed to stay in the market and not to create new companies; the mostly adopted strategy is about the creation of an hub by the government, usually in technical universities, where access to capital and help in terms of infrastructure availability and data access are supplied.

Chapter 2

Venture Capitalists

Venture Capitalists are institutional investors who provide capital to a company with high growth potential in exchange for a stake in the share capital. They are very important players in investing in growing and high-risk industries where the outcome of the investment will not be guaranteed. This type of investor operates by managing a fund and the companies financed are generally startups that have a high probability of bankruptcy or small companies that would like to expand but do not have sufficient capital to do so or simply cannot be listed on the stock exchange.
In both cases, if the investment proves to be a success, the economic return is so great for the venture capitalists that they are able to make up for the losses of other negative operations. The capital invested has no maturity or redemption date, the investor's return will be directly proportional to the creation of value in the financed company, of which he will be partly the owner.
Venture capitalists can intervene at various times in the life of a company, in the early stages (*early stage and seed financing*) or in the advanced stages when investments are needed to expand in the market (*early growth and scale-up*). Almost at the same level of venture capitalists there are *Business Angels*, private and non-institutional investor which invest in companies in the early stages of development and generally help with a high level of knowledge of the sector by providing technical and managerial skills.

2.1 Increasing interest in AI

The artificial intelligence sector has experienced high growth in terms of VC funding and an increasing number of new startups created. To better understand the evolution of the industry, some statistics that demonstrate the business potential of AI market will be reported below.

2.1.1 Market Revenue

A great interest and sensitivity towards AI has started to be felt since the middle of the last decade; in fact, in this period a massive development phase supported by national plans and private companies has started thanks to a continuous growth of the application sectors for this technology which has ceased to be merely research argument and has undertaken the process of real-life cases experimentation. However, the industry is only at the beginning of the commercial growth that promises to be explosive; the value of estimated future revenues is highlighted below in figure 2.1.

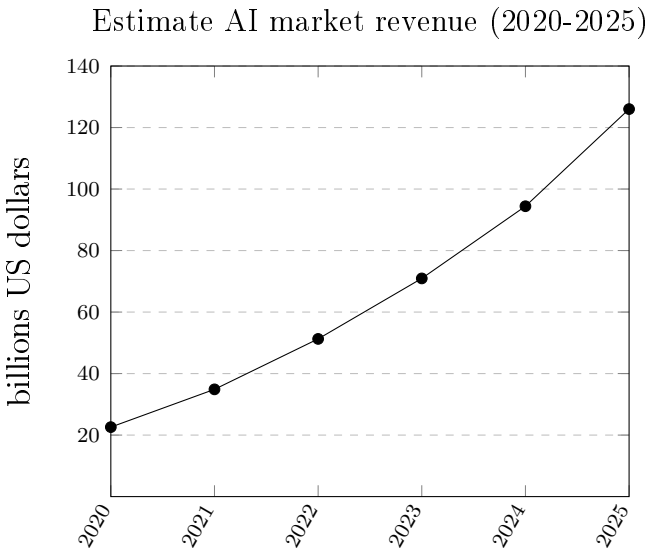

Figure 2.1: Estimate AI market revenue (2020-2025); Tractica, Statista, 2020

In figure 2.1 are showed the forecasts for revenues in the next few years identified by Tractica[1], a US market intelligence company that analyses

[1]for further information visit: `https://www.linkedin.com/company/tractica`

trends in the technology market. It is noted that the growth in profits is almost exponential, the market is expected to grow at an average rate of 40% more than in the previous year and to slightly exceed US$126 billion revenues in 2025.

The market opportunity has been understood by investors who have put a lot of money into the industry. From the Crunchbase[2] database, a leading platform collects information on investments and investors in public and private companies, the number of companies created between 2010 and 2018 that focus on Artificial Intelligence has been extracted and reported in figure 2.3 while in figure 2.4 is reported the amount of money invested in AI startups by VC.

2.1.2 New Startups

The figure 2.3 shows that the number of companies financed started to decrease after 2016 when reached the peak of 933. The decreasing number can be misleading; although the number of new open companies is becoming lower, the value of the funding contribution has increased, thus this decrease in the number of new companies can be translated into more money for the new and already exist businesses.

The graph must be interpreted according to the degree of maturity that the sector is reaching: the higher the level of development of the industry, the greater the amount of money that businesses need to make to take the next steps and resist maturity's competition. As proof of this, it can be seen that in 2018, according to Venture Scanner, funding is moving towards the later stage, AI seed financing decreased from almost 70% of funding events in 2013 to below 30% in 2018. In contrast, *Series B* to *Late Stage* financing in AI have increased from 15% of total funding events to 35% in the same time frame as showed in figure 2.2[46].

In a new developing market such as AI, competitiveness is very high, venture capitalists are in a hurry to achieve high profits in short terms and the sector is not yet well regulated; this is not probably the best way to develop a new business, thus the government's contribution to the defense of intellectual property and the creation of ad-hoc initiatives for the development and healthy integration of technology with the surrounding environment will be a

[2]for further information visit: `https://www.crunchbase.com/`

critical factor to avoid a new winter and the consequent lowering of interest, funds and quantity of research.

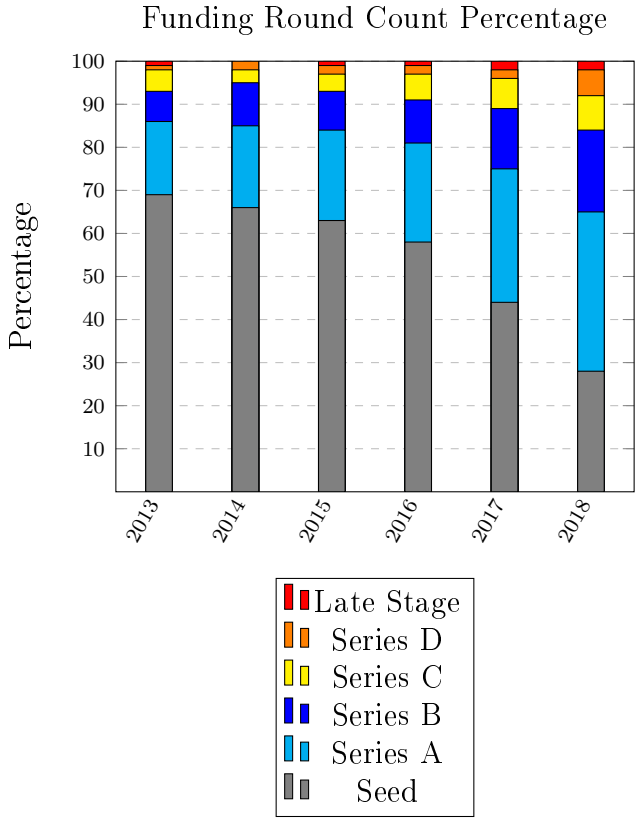

Figure 2.2: AI funding round count percentage (2013-2018); Venture Scanner, 2019

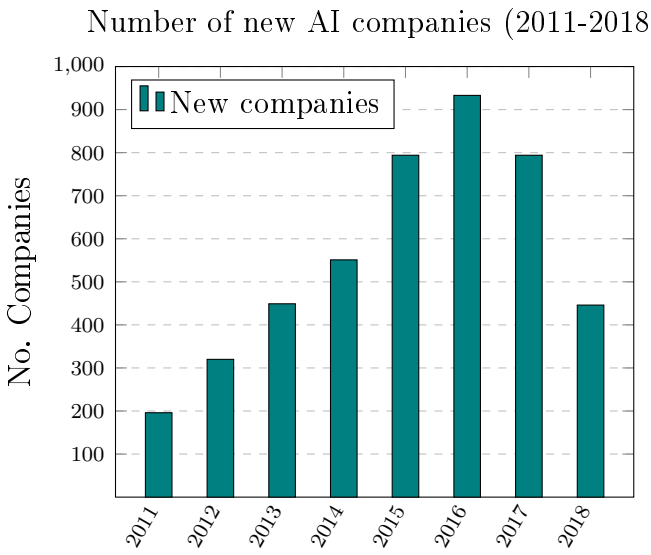

Figure 2.3: Number of new AI companies financed worldwide (2011-2018); Crunchbase, 2019

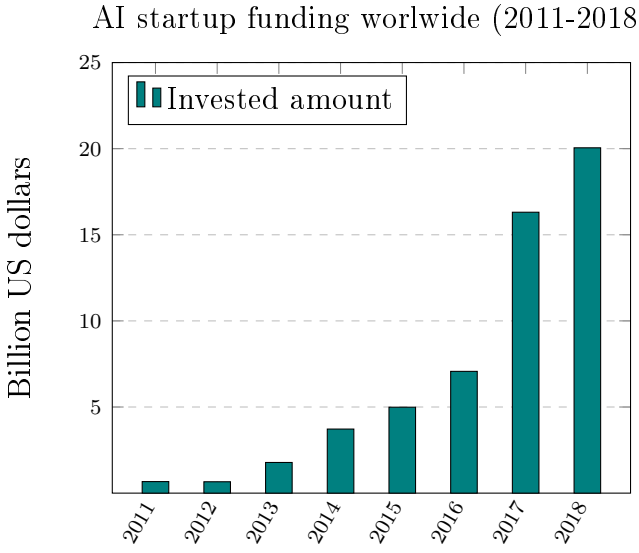

Figure 2.4: AI startup funding worlwide in billion US dollars (2011-2018); Venture Scanner, Statista estimates, CBinsights, 2019

2.1.3 VC Effects

A research about the localization of the 25 top venture capitalists among the best investors in artificial intelligence has been taken taken from Growthlist[47]; the results show that there is an imbalance of the investors' location towards the USA (19), probably due to the power of Silicon Valley based VCs, despite there is an important presence of VCs in Asia distributed among China, Hong Kong, Singapore and Japan which account for the remaining six top investors. At first glance it seems a localized competition between the USA and China; one possible metric used to analyze the race for technological dominance in AI could be the number of unicorns based in each country; once again China and USA are the main characters, there seems to be no competition and the results are reported in table 2.1.

Country	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Total**
USA	1	2		3	7	9	2	**24**
China			1	2	6	2		**11**
UK		1			2	1		**4**
Israel					2	1		**3**
Canada						1		**1**
France						1		**1**
Japan					1			**1**
Singapore						1		**1**

Table 2.1: Number of AI unicorns per year of join (2014-2020); CBinsights, 2020

According to CBinsights[48] there are almost 500 unicorns (private companies that have reached a valuation of over one billion dollars) worldwide. Of these around 10% are artificial intelligence companies (46); the table 2.1 shows for each country the number of unicorns and the year in which they became one. The countries with the highest number are again China and USA, countries in which there is an high density of VCs and where the AI topic is strongly supported. In US there is a large supply of VCs funding companies especially in the Silicon Valley in California, an area where in 2018 was the final destination of about US$77 of the total US$140 billion funds by VCs in the whole country[49]. The totality of AI companies in USA

raised US$9.3 billion in 2018, a 72% increase compared to 2017, as shown in figure 2.5 . US growth and dominance may seem unparalleled but according to Venture Scanner, China demonstrated even stronger growth, increasing eight-fold from US$1 billion in 2016 to over US$8 billion in 2018 by VCs financing in AI; this rate shows that it seems there is an increasing investors' interest into Chinese companies, probably due to a tailor-made environment where high competition and data availability combined with a gigantic user base can boost the whole industry. For comparison with the rest of the world by funding amount raised from venture capital, in 2018, artificial intelligence startups in the UK raised US$1.3 billion, almost as much as the rest of Europe combined; in the same year should be noted a remarkable example as the US$200 million in funding from Graphcore[3][50]. Despite the efforts of many countries, it looks like from VC perspective it is better to invest in AI companies based in USA or in China.

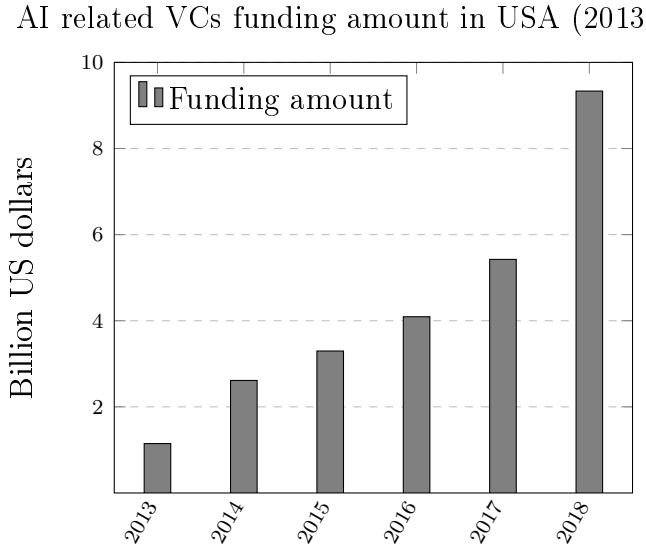

Figure 2.5: AI related VCs funding amount in USA (2013-2018); Pwc, MoneyTree-Report, 2018

The ultimate goal of an investor, however, is not to invest and not receive money back, but to earn as much money as possible through the acquisition by a larger company than the financed one or through an IPO. Even in this situation, the AI sector is showing unparalleled growth. The number of startups acquired has been growing steadily since 2013 and at a high rate, as

[3]for further information visit: `https://www.graphcore.ai/`

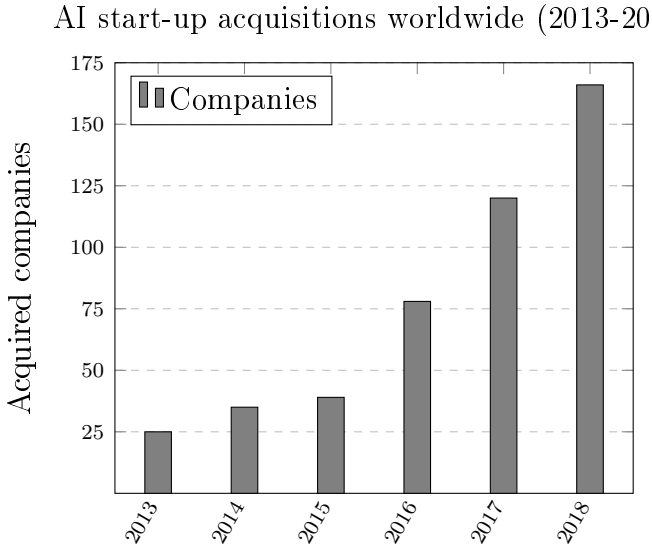

Figure 2.6: AI start-up company acquisitions worldwide (2013-2018); Statista, 2019

can be seen from the figure 2.6 . A better explanation about the acquisitions and IPOs from AI financed companies will be given in the next chapter 3.5 .

2.1.4 First conclusions

The market for artificial intelligence seems to be unstoppable. Growth in terms of profits and new companies created seems to be accelerating in the immediate future. However, the level of research and development appears to be good enough to begin to see a first phase of market growth in which funding begins to be useful not for the creation but for the proliferation of a business already started.

The interest in the subject is very strong, just look at the number of startup acquisitions or the amount of money provided by VCs to get an idea. Although the phenomenon is felt and spread all over the world, the USA and China are much more advanced in the development of technology; in the USA the growth process of AI has been gradual over time and it has been the natural continuation of a process of technological evolution thanks to a lively entrepreneurial environment, sponsored by local hubs and unbalanced in the technology sector, and the presence of large capital to invest; in China the situation is slightly different as the growth has been dictated by the need of a central government to succeed in creating a strong nation to become the world's leading power and has seen AI as the main road; In China the ecosystem that is being created seems to be so strong and well established that it can really become a leader in development and research, even if the road is not easy to follow because the country seems lacking the long experience in sensing and controlling technology that the USA possesses and that it is not possible to acquire in a short time, in a sort of time compressing diseconomies that does not allow to generate and sustain a competitive advantage. Despite this, the great advantage of China lies in the fact that it has different types of data all concentrated within a single entity rather than having a lot of different data distributed over several centers, as for example in the USA where each individual company collects only the data of its industry and not all of them; for example a company collects data on gastronomic preferences, one on travel, one on online purchases, in China it is all in the hands of a single player; if the crucial ingredient for AI is the great variety and quantity of data, perhaps it is China that is ahead in this case.

One of the difficulties that are beginning to be encountered in the sector is the lack of experienced and skilled AI scientists who can be really useful in the implementation of new software; new degree programs are being created in every part of the world and more and more private companies are investing funds in the training of their employees; the lack of experience and

the shortage of experts in the field could shake up the business but there are systems that have proved to be at least so far successful and what is happening in China is an example; a winning ecosystem is being created in which the retention of talent is high and where, thanks to the large amount of money from government and VCs, the country is starting to be attractive to many top researchers. Combining together the low supply on the market of industry's experts, market maturation and the need for VCs to see immediate profits, the business is starting to be very expensive and the risk that a good idea will be squeezed out is very high; at the same time in this complex ecosystem a race for AI supremacy between USA and China is ongoing and the result is very unclear.

At this point, after knowing well the state of the art and the advancement of technology, and having analyses various economic indicators of the industry, the next question seems quite obvious and natural: what leads VCs to invest in AI in a given country? What are the fundamental discriminant that make one country more attractive than another for AI investments and AI related company creation? What are the basic requirements and where is the key for the strength showed up by countries dominating the industry?

Chapter 3

Panel data model

3.1 Purpose of investigation

It has been seen that in recent years artificial intelligence has been the hot topic for academic research and funding by VCs; given the youth age of the industry, large amounts of funds were invested before the industry began to show early signs of maturity. In these cases the only sources of investment are the VCs and personal funds as banks drive very risky the money lending. The questions to which an answer is expected to be given with this research are related to the necessity to understand the drivers that have driven VCs to finance AI early stage businesses; then to foresee in which country is it more appropriate to invest in AI in order to increase the probability of successfully the investment and what are the variables that should be to taken into account.

The ultimate goal of this research is to understand the most favorable environment in which AI-related businesses can arise; in this way, the outcome of the analysis can be useful to investors who may have guidelines on which countries continue to divert funds for the new maturity reached by the industry, but also to young entrepreneurs who have a brilliant idea to develop but need money to start their own business. In addition, the outcome can also be useful to scientists and academic researchers who want to undertake a career path related to the world of AI.

The last group who might be interested in the outcome of the research could be the local governments who see AI as the future of their country and want to take ad-hoc measures to stimulate their territory in the development of this technology. In this case, they could take the example of countries

where AI has exploded, then understand the points on which to act at the legislative level for the creation of AI-friendly environment.

This chapter is organized in sections as follow: review of the actual literature, hypothesis discussion, data collection, summary statistics, regression model, output discussions and suggestions for future research..

Keywords: Venture Capital, Artificial Intelligence.

3.2 Literature Review

The investment in artificial intelligence by venture capitalists is an opportunity that has arisen in recent years. The literature on the drivers of VCs investment in AI is very rare but the model of analysis that is to be conducted is very similar to the one done by Cumming, Schwienbacher (2018)[51], Haddad, Hornuf (2019)[52], Gazel, Schwienbacher (2020)[53] who have investigated the main economic and political determinants that led venture capitalists to invest in fintech startups and found that a well-developed economy and an easy access to venture capital are the favorable conditions for the proliferating of the business; the same kind of research was done by Kelly (2012)[54] as investigation about structural drivers for private equity investments activity. All the previous papers used a regression model to estimate the most important factors a company should have for an investors to put money into an early stage; all the data were organized by country and year, the dependent variable of the model was the number of company created.

When an industry is on the launch pad, the risk of failure is very high, but without investments from third parties it would be difficult to innovate; among the ingredients for success are funds and the experience of a business angel to drive the management especially in SMEs and high-tech start-ups Madill, Haines, Riding (2005)[55]; on the other hand a positive effect generated by risky investments from VCs is the creation of innovations. It is showed that innovation and risky investments are closely linked Hirukawa, Ueda (2011)[56], Arvanitis, Stucki (2013)[57], Dushnitsky, Lenox (2006)[58] while the local effects on innovation and VCs can be found in China as investigated by Ni, Luan, Cao, Finlay (2014)[59] or in Germany Darin, Penas (2017)[60].

The advantages offered by VCs for a financed company are not limited to the simple contribution of capital but are important because they positively

contribute to the growth of the business Davila, Foster, Gupta (2003)[61] Manigart, Sapienza (2017)[62] especially the one related to high-tech market Colombo, Grilli (2010)[63], Colombo, Luukkonen, Mustar, Wright (2010)[64]. In order to attract VCs among the main ingredients as well as an innovative business idea and a feasible business plan there are patents; Patents are the character that create a competitive advantage and are a crucial resource because increase the company visibility on the market and the probability to have easy access to funds Häussler, Harhoff, Mueller (2013)[65], Hoenig, Henkel (2015)[66].

Due to the novelty of the AI sector, it sometimes happens that development and implementation of technology are way faster than legislation; researchers suggest that policies which encourage transparency and sharing of large datasets across both public and private actors can stimulate a higher level of innovation-oriented competition, and also allow for a higher level of research productivity Agrawal, Gans, Goldfarb (2017)[67]. Many other are questioning about the effect of AI on the other sectors and other technologies, but first there are fundamental policies which should be implemented that may be salient in the influence on the diffusion of AI, like ones related to labour and antitrust Agrawal, Gans, Goldfarb (2019)[67] and Calò (2017)[69].
At the same time there is concern about the unpredictability and uncontrollability of AI, and in this directions transparency and explainability of AI by creators should be called by legislator and a suggestion for scholars is to have a look at the bias in the algorithms output, as in Buiten (2019)[70].

Another important topic in the rest of the literature on artificial intelligence is very focused on the effects in the job market and ethics. Specifically, AI may dominate human labour leading to unemployment for many workers but for sure will create new professional figures Wilson, Daugherty, Morini-Bianzino (2017)[71]; AI will also be the main source of inequalities in society and income distribution in the upcoming future, Korinek, Stiglitz (2017)[72]. From an ethical perspective it seems that AI entities do not have the moral sense to make ethical decisions Etzioni, Etzioni (2017)[73] and ethical choices should be taught to machines Yu, Shen, Miao, Leung, Lesser, Yang (2018)[74]; since automatic assistants and robots are now becoming loyal teammates, it would also be correct to understand what the consequences of a guided choice may be and on which party would be to blame in the event of a catastrophe Dignum (2018)[75].

3.3 Hypothesis and Variables

The aim of the research is as announced to be able to understand which are the drivers that lead to the investment by VCs and formation of companies in AI industry. After an analysis of the rapidly growing sector, three main clusters have been identified within which to insert the variables that will become part of the regression model; clusters have been useful at the moment of the creation of the hypotheses to be tested. The clusters are peculiar to the industry and are: *Entrepreneurial*, *Governmental* and *Labour Market*.

3.3.1 Entrepreneurial cluster

Hypothesis 1: *VC's investment in AI related companies is facilitated in countries with easier access to funds and a high concentration of venture capitalists.*

This is the first hypothesis to be tested by the model to assess the vivacity of the business environment. The literature concerning the positive contribution to the creation of new businesses thanks to the high presence of VCs is very wide. Specifically, many studies have been carried out to understand the positive effects of a geographical cluster within which there are three main ingredients as high concentration of entrepreneurs, VC concentration and business ideas as a fuel for an increase in the number of companies operating within an area Kuechle (2014)[76]; the entrepreneurial activity and the creation of new know-how, in general, is a resource of skills that could be transformed into new businesses, thanks to spin-offs, in which former employee take advantage of the knowledge acquired before Samila, Sorenson (2011)[77]. To try to incorporate this first piece of information, the index used was *Venture Capital Availability* taken from the global competitiveness database, and consists of a range of values from 1(low) to 7(best) which reflect the presence of Venture Capital in a given country per year.

It is not easy to create business or run a company in every country; difficulties in a day by day operations are different all over the world, there are some places where it is easier to translate an idea into reality thanks to the help of incubators or the presence of entrepreneurial mentality linked to the territory Dubini (1989)[78] or because the number of procedures, time and minimum capital required are reduced. All this information is contained within the variable *Starting a Business* taken from the doing business

database in which for each country for each year is assigned a score that takes into account many factors that influence the ease of creating a business.

A company that is born from scratch is difficult to be exaggerate in dimensions and revenues volume, the usual process consists in starting from small size, serve a small niche of market and then after a significant growth over time there will be the chance to be acquired and become part of some larger company. One way to finance initial expenses, in addition to personal savings or the possibility of receiving financing from VC, is certainly the ease of access to credit from banks; an innovative idea is almost always synonymous with a risky idea and it is perhaps difficult to receive funds Black, Strahan (2002)[79] and Banerjee, Breza, Duflo, Kinnan (2018)[80]. To include this feature in the model the *Ease Access to Loans* index has been considered, from the global competitiveness database which gives a score from one to seven to each country per year based on the ease of receiving funding from banks with only a good business plan and no collateral.

To evaluate the quality and motivation of the entrepreneurial activity it can be useful to look at the number of applications for patents Gabrielsson, Politis, Dahlstrand (2013)[81]. A patent owned by an innovative company significantly increases the chances of being able to be financed by a VC or to easily receive funds Häussler, Harhoff, Mueller (2013)[65], Hoenig, Henkel (2015)[66]; in this case the variable *Patent Applications* has been inserted in the model reflecting the number of patents applications per year per country, taken from the World Bank database, considering applications from residents and non-residents.

Given the nature of the business of artificial intelligence, it would have been appropriate to include the large availability of aggregated data among the determinants. Unfortunately, it was not possible to identify an index that would return this value, so this factor was not taken into account.

3.3.2 Governmental cluster

Hypothesis 2: *an industry sector if assisted by the government with development plans, funds and favorable legislature is much more likely to grow and attract investors and funds.*

Within the sphere of control by the central government, a reluctant topic

is taxation. An entrepreneur can choose to open a business in a country where taxation is lower or at least facilitated for new activities; in the same way a VC can prefer the financing of companies where taxes are lower. In the past, literature has already dealt with this issue and the final result indicated that taxation does not in any way limit entrepreneurial activity Bruce, Mohsin (2006)[82] and Bruce, Liu, Murray (2015)[83] . Considering in this case the young age of the AI sector, the *Tax Burden* index from the Heritage database[1] has nevertheless been included in the system; the index is a numerical value in a range, the higher the level of tax pressure per country per year and higher the value of the index.

It has been seen that artificial intelligence requires large amounts of data that are sometimes difficult to collect because they are spread over several collection centers. The main central governments are moving in this direction, in fact they are trying to implement policies able to make available large amounts of reliable data in the hands of companies dealing with AI. In addition to the data, large amounts of public money are funding AI projects in all universities around the world; research and development is undoubtedly a key aspect that drives the evolution of technology Ács, Audretsch, Braunerhjelm, Carlsson (2005)[84] and Raymond, St-Pierre (2010)[85] and if support given by the government is significant, it can generate accelerations that the private sector alone would not be able to create, see paragraph 1.7. For this reason the amount of *GDP in R&D* invested by each country per year in research and development has been included in the model.

In order to test whether the level of wealth pro capita of a country is decisive in the creation and financing of companies in the AI sector, the *GDP per capita* variable extracted from the World Bank database has been taken into account; studies positively relate the growth of the gdp to a high entrepreneurial activity Acs, Audretsch, Braunerhjelm, Carlsson (2011)[86]. Yartey (2008)[87] also suggests that income level is a good proxy of capital market development.

An investor may prefer an investment in a country where legislation is more conducive to business development, where legislative barriers at entry are weaker Bailey, Thomas (2017)[88]; moreover, legislative barriers are also the result of limitations to local business activity Klapper, Leaven, Rajan (2006).[89] The ability of a government to create laws and enforce them becomes a competitive advantage factor when it comes to developing countries

[1]for further information visit: `https://www.heritage.org/index/`

where compliance with laws and the creation of ad-hoc rules can increase the flow of capital into the country and thus encourage innovative business ideas Jadhav (2012)[90] and Jalilian, Kirkpatrick, Parker (2007)[91]. In the *Regulatory Quality* index taken from the worldwide governance indicator database, it is assigned a score based on how much the government of a country in each year has been able to implement policies and regulations that permit and promote private sector development.

the AI industry is very attached to the intellectual protection of the work done. Specifically, protection is necessary on the side of the business owners who can in this way defend themselves against possible copies of their algorithm and at the same time the intellectual protection serves to defend what has been created by the artificial intelligence. For the second situation, the existing literature refers to insufficient and inadequate legislation on the subject Davies (2011)[92] it is in fact required that AI should be recognized as a legal entity Gurkaynak, Yilmaz, Doygun, İnce (2018)[93] and DaCosta, Carrano (2017)[94] but the debate is still open. However, a legislature that guarantees adequate protection remains fundamental; in this way, an investor can be spurred to invest in a country if he has a defense guarantee; to integrate this parameter, the variable *Intellectual Property Protection* has taken from the global information technology report where for each year in each country a score is assigned in a range from one to seven.

Finally, the last variable in this cluster with the ambition to have a global view of the macro-area is the *Human Freedom* index taken from the Fraser Institute database[2]. Artificial intelligence needs a lot of data all at once in order to work effectively, easy access and data collection from people habits can be fertile ground for business and investment from outside; because of this type of technology, less privacy and freedom of the citizen corresponds to a large data collection Jin (2018)[95] and Manheim, Kaplan (2019)[96]. An example would be China where a central government constantly monitors its citizens, reducing their privacy and freedom, see paragraph 1.7.

[2]for further information visit: `https://www.fraserinstitute.org/economic-freedom/dataset`

3.3.3 Labour Market cluster

Hypothesis 3: *the presence of high skilled AI workers is more likely to attracts investment from VCs.*

Artificial intelligence is a type of technology that requires high mathematical and computer programming knowledge. Creating a business in this field requires not only a good idea and an excellent business plan but also technical skills that in most cases are possessed by engineers, mathematicians or computer scientists so that artificial intelligence experts are in high demand but in shortage of supply worldwide. Two variables have been taken into account to combine this characteristic with the regression model: *Engineering Universities per million inhabitants* and *Quality of Math and Science education.* the number of universities per engineering path per country has been extracted from the TopUniversities[3] website database, which every year compiles a ranking of top universities (QS ranking) and collects information about all universities worldwide; the number of universities was considered constant over time, there weren't considered variations in this number for the time interval taken into account (2007-2017). For the calculation of the index, the number of universities was then divided by the number of inhabitants in millions through personal calculations. The value of the index quality of math and science education was instead extracted from the Global Information technology report where each year a score is assigned to each country based on the quality of mathematics and science teaching; the data is collected through a survey to a representative sample of the population.

Innovative business ideas may arise because of the presence of experts in the field or out of necessity; specifically, the world of labour market is fundamental to the current analysis as a high level of unemployment can lead to the stimulation of people's entrepreneurial motivation and create new business, especially in countries where social support for unemployment is low or underdeveloped Cowling, Bygrave (2011)[97] or where youth unemployment rate is very high Chidiebere, Iloanya, Udunze (2014)[98]. In this regard, therefore, the value of the variable *Unemployment rate* has been taken into account for the model; on the same line of reasoning, in order to have a broad view of the cluster, the *Labour Freedom* index extracted from the Heritage database has been taken into account that within a range of values contains for each year for each country a measure of the regulations for hiring a worker, ease of layoffs, minimum wage and maximum daily working hours. Having

[3]for further information visit: `https://www.topuniversities.com/`

low cost skilled workers can reduce costs in a sector where costs are allocated mainly to workers' salaries and at the same time it can push investors to prefer investment into one country over another; an example of this is India, where there is a high concentration of low cost skilled workers in information technology, which has been the destination of offshoring business in IT from all over the world Ravishankar, Pan, Myers (2012)[99] and increased the entrepreneurial activity in the country Todd, Javalgi (2007)[100].

3.4 Data

The source of the data used for the dependent variable is the Crunchbase database, which contains detailed information on artificial intelligence funded startups and investor information; it is not the first time this dataset has been used, with the same data Haddad, Hornuf (2018)[52] and Cumming, Walz, Werth (2016)[101] have already worked with.

The data are updated on 08/04/2020; the starting database contains 120,429 lines, corresponding to the same number of startups financed from an interval of time from 1900 to 2020 and operating in various sectors. For each of them is reported the complete biographical data, year of foundation and sector in which it operates but not the amount of money collected or the financing rounds. For each company there are two levels of detail, one macroscopic and one more precise; the less precise level of detail has been taken into account and therefore all the startups that had the "artificial intelligence" item in this column have been extracted. From the starting database 5,469 companies have been exported for the purpose of this research. What is needed for the analysis, the dependent variable of the model, is the number of AI companies created in each country in each year. The idea is to build a data panel on which to perform a regression analysis and identify among the variables explained in the previous paragraph 3.3 which ones are more significant in the creation and funding of AI companies.

Of the total 5,469 useful items, not all of them were used; in the database many lines were incomplete about the information of the country of belonging or the date of foundation of the company and for this reason they were excluded; to be precise 339 were not used so the number of useful ones decreased to 5,157. The artificial intelligence phenomenon is a relatively recent, but nevertheless many companies that now deal and innovate with AI have been created in the past, such as Google (2005) or Intel (1968) and appearing in the database; in order to have a sharper image of the phenomenon in recent years, only the companies created since 2007 have been taken into account; counting has started from this year onward, so the total usable database entries have dropped to 4,907.

The database on which the research has been done, was built with macroeconomic indicators taken from global free-access databases that collect the information required. Data such as *GDP per capita* or *Unemployment* are easily available as macro-indicators widely used and therefore calculated with high precision; other indicators, on the other hand, were incomplete: it was

not possible to have exactly all the indicators for all the years of the countries considered, especially for the smaller economies, for which it is more difficult to collect data specifically; on the contrary, for the major powers such as the USA, European countries or China, the indicators are completed with no missings.

The biggest criticisms were encountered in the *Ease Access to Loans* and *Quality of Math and Science Education* indexes. for both were missing values from 2018 onward, it was decided not to estimate them ,by interpolation taking into account the historical data series, in order to have a better accuracy in the representation of the results: another factor, *Regulatory Quality* was also missing data for the year 2019. Among the exclusions due to lack of data and to make up for the time lag with which the data are entered in the Crunchbase database, the final choice was to consider all the companies created from 2007 to 2017, for a total of 4,256 companies complete with all the information for all the indicators considered.

A further reworking of the values entered was due to the fact that the values were not very comparable with each other and could have led to results that were difficult to interpret. For the *Labour Freedom*, *Tax Burden*, *GDP per capita* and *Starting a Business* and *Patent Applications* indexes, it was not their punctual value but their natural logarithm that was considered in order to contain the information of the data but to avoid managing different orders of magnitude: the values of the dependent variable have maximum values in the order of hundreds, the number of patent applications sometimes exceeds one million.

The database from Crunchbase is very unbalanced towards the US entrepreneurial ecosystem. Of the 4,256 available observations, almost half of them reside in the USA and this can be a threat to the validity of the expected results; two other models will be proposed to overcome this problem. In the first model an analysis will be carried out on all the companies excluding those in the USA while in the second model all the available data will be included but the number of companies created outside the USA will be multiplied by four and then the regression analysis will be carried out; in this way the ratio will be 4:1 for the rest of the world, so the excessive amount of data from the USA will be flattened.

3.5 Summary Statistics

This chapter will present the descriptive statistics of the data that have been used for the analysis. The built database is a panel data dataset, where for each country for each year the number of new startups created is indicated. In the first table 3.1 there is a descriptive information of the companies that are inserted in the database; at first impact it is noted that the growth of new startups financed has been constant and at a high rate (variable *Created*); the peak of new businesses opened has been in 2016 (896) and up to that moment the rise has been impetuous; 2017 shows a slight decrease in new formations (776).

Year	Created	Operating	Acquired	IPO	Closed
2017	776	755	16	0	5
2016	896	853	29	0	14
2015	774	719	40	1	14
2014	532	474	44	0	14
2013	440	379	47	0	14
2012	309	255	44	0	10
2011	191	141	35	5	10
2010	130	101	22	2	5
2009	96	69	22	1	4
2008	66	45	13	4	4
2007	46	32	11	1	2
Total	**4256**	**3823**	**323**	**14**	**96**

Table 3.1: Status of companies in database (2007-2017); Crunchbase, 2020

Looking at the data in the table, the dare that strikes is that the AI one, this time does not seem to be a passenger business; in the column *Operating* the companies that are still alive in 2020 are indicated. The percentage of the operating companies on those created for each year is obviously a decreasing value going back with time and higher in recent years, but anyway if we consider 2015, 5 years after the creation, more than 97% of the total companies are still operative: have been acquired, listed on the stock market with an IPO or are simply operating.

The columns containing the most interesting information are perhaps *Acquired* and *IPO*. As regards the number of companies acquired is obviously

greater going back in time; the startup has had the time to grow, gain experience, consolidate its business model and be acquired by a larger company. The number of IPOs seems to be inexplicably low, it would have been fair to expect a large number of listed companies, but probably, given the nature of the Crunchbase data very focused on companies that VCs have invested money in, the figure is therefore not misleading at all, it requires time to reach an IPO, AI is still a young business.

Table 3.2 shows the number of companies created per country per year for the nine countries with the highest number of companies created in total over the ten years, indicated in the last row *Total* of the table below. The results are quite in line with expectations, the USA dominating the scene with 1,978 companies created, followed by United Kingdom and China completing the podium. In this case it should be noted that the UK has a higher number of startups created than China but the development of technology seems to have started earlier than in China; to demonstrate it by the numbers: China has reached 10 startups created annually in 2013 while in the UK 10 AI startups were already exist in 2009, four years earlier; however, the sensitivity to the issue of AI in the UK is very high, investments are increasing dramatically: in 2018 US$1 billion dollars were funded, the same amount was reached just in the first 8 months of 2019 alone[102].

Year	**USA**	**GBR**	**CHN**	**CAN**	**FRA**	**ISR**	**IND**	**DEU**	**SGP**
2017	324	76	51	36	15	26	27	31	20
2016	409	79	57	34	40	31	32	26	17
2015	344	75	55	37	28	30	40	30	14
2014	262	60	32	18	27	22	10	14	7
2013	219	50	19	17	16	13	11	11	5
2012	139	43	10	9	8	12	10	8	5
2011	111	17	7	6	8	6	5	7	1
2010	60	15	7	7	6	3	5	3	1
2009	53	10	2	3		7	3	3	2
2008	34	5	3	2	4			2	
2007	23	4	3	3	3				
Total	**1978**	**434**	**246**	**172**	**155**	**150**	**143**	**135**	**72**

Table 3.2: AI startups created per country per year, top 9 countries (2007-2018); Crunchbase 2020

Table 3.3 at first impact is the natural continuation of table 3.2. It shows for each year and for each country the number of companies acquired from only the nine top countries with the maximum value in acquisitions. Once again the United States dominates, followed by UK and Canada completes the podium with third place. What is misleading is the total lack of Chinese companies. From the entire Crunchbase database, it results that only one Chinese company was acquired in 2014; the number is very low compared to countries that have fewer number of companies created in AI, but have had a greater number of acquisitions like Canada, France or Israel.

Year	USA	GBR	CAN	FRA	ISR	DEU	IND	ESP	NLD
2017	10	1	1	0	1	0	1	0	0
2016	22	0	2	0	1	1	3	0	0
2015	28	3	1	1	3	1	1	1	0
2014	35	1	1	3	0	0	0	0	0
2013	33	1	0	1	3	3	1	1	1
2012	27	7	1	1	0	2	0	0	1
2011	27	1	2	1	1	1	0	0	0
2010	13	2	4	1	0	0	0	0	1
2009	18	1	1		1	0	0	0	
2008	7	3	0	2		1		0	0
2007	5	1	1	2				1	0
Total	**225**	**21**	**14**	**12**	**10**	**9**	**6**	**3**	**3**

Table 3.3: AI startups acquired per country per year, top 9 countries (2007-2018); Crunchbase 2020

As already indicated above, in order to be able to cope with the over-population of the numbers of companies created in the USA and therefore to have a high risk of unclear results of the global situation, the number of companies created in the other states excluding the USA has been multiplied by four. We have passed from an almost 1:1 ratio to a 1:4 ratio; three models will be proposed, the one with the totality of the data and the ratio (created in USA:created in the rest of the world) equal to 1:1, a model in which the ratio will be 1:4 and finally the model where all the data in the database will be used without those of the USA to verify if there are contrasting effects between the results and to test the validity of the analysis done. Below is represented in table 3.4 a summary of descriptive statistics about the value of the model's independent variables with the original ratio 1:1 and in table

3.5 a summary about the source and detailed insights of the factors taken in consideration.

In table 3.4 in the Obs column the number of observations reported is 336; this number corresponds to the number of rows in the database, the real number of startups from which the calculations will be originated is 4,256.

Variable	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
Created	336	12.67	40.66	1	409
Entrepreneurial cluster					
Ease Access to Loans	336	3.49	0.91	1.58	5.67
ln.Patent Applications	336	8.75	2.27	1.95	14.14
ln.Starting a Business	336	4.44	0.13	3.82	4.60
Venture Capital Availability	336	3.37	0.83	1.75	5.70
Institutional cluster					
GDP in R%D	336	1.75	1.04	0.11	4.82
Human Freedom	336	7.84	0.89	4.49	9.06
Intellectual Property Protection	336	4.79	1.07	2.33	6.58
ln.GDP per capita	336	10.03	0.98	7.00	11.54
ln.Tax Burden	336	4.19	0.21	3.50	4.60
Regulatory Quality	336	2.52	0.80	0.30	3.76
Labour Market cluster					
Engineering Universities x million	336	0.73	0.61	0.02	3.51
ln.Labour Freedom	336	4.13	0.25	3.43	4.61
Quality Math and Science edu.	336	4.45	0.96	1.88	6.48
Unemployment	336	7.54	4.49	0.49	27.10

Table 3.4: Summary of descriptive statistics for variables organized in clusters

Index	Description
Ease Access to Loans	In your country, how easy is it to obtain a bank loan with only a good business plan and no collateral? Range [1 = extremely difficult; 7 = extremely easy]. World Economic Forum, Global Competitiveness Database
Patent Applications	Number patent application in a given country from residents and non-residents. World Bank database
Starting a Business	Measures the number of procedures, time, cost and paid-in minimum capital requirement for a small-to medium-size company to start up and operate in each economy's largest business city. Range [0;100]. World Bank, Doing Business database
Venture Capital Availability	In your country, how easy is it for entrepreneurs with innovative but risky projects to find venture capital? Range [1 = extremely difficult; 7 = extremely easy]. World Economic Forum,Global Competitiveness database
GDP in R%D	%gdp expenditure from government in reasearch and development per year per country. World Bank database
Human Freedom	The Human Freedom Index is a global measurement of Personal, Civil, and Economic Freedom. Range [0;10]. Cato Institute, Fraser Institute, and the Friedrich Naumann Foundation for Freedom
Intellectual Property Protection	In your country, to what extent is intellectual property protected? Range [1 = not at all; 7 = to a great extent]. World Bank database, Global Information Tech report
GDP per capita	Gdp per capita per country per year in current dollar. World Bank database - World Development indicators
Tax Burden	Measure of the tax burden imposed by government. Includes direct taxes, and overall taxes, as a percentage of GDP. Heritage database
Regulatory Quality	Perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development. Range[-2.5;2.5]. World Bank database, Worldwide Governance indicator

Index	Description
Engineering Universities x10^6	Number of engineering universities per million inhabitants, own calculations. World Bank database, Top Universities
Labour Freedom	Quantitative measure considers aspects of the of a country's labor market, including regulations, minimum wages, laws inhibiting layoffs, severance requirements, and restraints on hiring and hours worked. Range [0-100]. Heritage database
Quality of Math and Science Education	In your country, how do you assess the quality of math and science education? Range[1 = extremely poor ; 7 = excellent]. World Economic Forum, Global Information Technology report
Unemployment	Unemployment rate on total labour force. World Bank database

Table 3.5: Description and source of indexes

In the matrix below is reported the regression model used for the estimation of coefficients, where i stands for the country and t for the year.

$$Nr.Created_{i,t} = F \left(\begin{array}{c} EaseAccesstoLoans_{i,t} + ln.PatentApplications_{i,t} + \\ ln.StartingaBusiness_{i,t} + VentureCapitalAvailability_{i,t} + \\ GDPinR\&D_{i,t} + HumanFreedom_{i,t} + \\ IntellectualPropertyProtection_{i,t} + ln.GDPpercapita_{i,t} + \\ ln.TaxBurden_{i,t} + RegulatoryQuality_{i,t} + \\ EngineeringUniversitiesxmillion_{i,t} + ln.LabourFreedom_{i,t} + \\ QualityMathandScienceedu._{i,t} + Unemployment_{i,t} \end{array} \right)$$

3.6 Regression Model

The dataset at our disposal is a panel data. The panel data consists of the storage of different variables, each in a series of time periods; in our case, the dependent variable observed was *Created* and represents the number of companies financed in AI. For each country for each year, data were collected to populate the database; however, the database is not balanced. Not all countries have enough data to cover the entire time span from 2007 to 2017. Specifically, in some cases, no new startups have been created and therefore they have not been included in the model; the years in which there was no entrepreneurial activity in the AI sector for a country do not enter the model, specifically there is not a line for each country that indicates the number of new companies created equal to zero. The regression model chosen for the analysis is a random effect regression for longitudinal data. The appropriateness of using this analysis technique applied to a panel data database is documented in Laird, Ware (1982)[103] and Hedeker, Gibbons (1994)[104]; however the same kind of analysis has been done by Cumming, Schwienbacher (2018)[51] and Haddad, Hornuf (2019)[52] for fintech startups and venture capitalist.

Table 3.6 shows the outputs of three different models:

- **Model 1** refers to the totality of the database without any modification. In this case the United States weighs half the total observations.
- **Model 2** where the weight of the United States is reduced by multiplying the number of created companies in the rest of the world by an arbitrarily chosen coefficient equal to 4. This step has been carried out to reduce the weight of the USA and reduce the possibility of having biased results without a global vision at the level of determinants in the single country.
- **Model 3** the sample used refers to the whole world except the USA's observations.

In the graphic representation in table 3.6, next to the name of each independent variable the estimated coefficients are shown, the standard deviation is included between brackets () and the Significance level is represented by an asterisk: *10% significance, **5% significance, ***1% significance.

Explanatory Variable	**Model 1**	**Model 2**	**Model 3**
Entrepreneurial cluster			
Ease Access to Loans	-3.823	-15.161**	-12.140**
	(4.188)	(6.264)	(5.184)
ln.Patent Applications	6.620***	12.850***	9.789***
	(1.589)	(2.024)	(1.857)
ln.Starting a Business	51.736**	107.408***	96.437***
	(23.231)	(31.844)	(27.274)
Venture Capital Availability	4.856	15.199**	8.548
	(5.563)	(7.909)	(6.847)
Institutional cluster			
GDP in R%D	-0.658	-1.069	-0.103
	(3.718)	(4.776)	(4.164)
Human Freedom	11.042*	7.806	-2.478
	(6.378)	(8.757)	(7.586)
Intellectual Property Protection	2.753	10.693*	11.362**
	(4.875)	(6.811)	(5.801)
ln.GDP per capita	4.322	-4.541	-8.906
	(5.622)	(7.494)	(6.463)
ln.Tax Burden	7.942	3.562	0.934
	(15.71)	(20.116)	(17.634)
Regulatory Quality	-19.878**	-14.279	2.742
	(9.898)	(13.688)	(11.862)
Labour Market cluster			
Engineering Universities x million	5.832	12.397*	8.629
	(5.611)	(7.228)	(6.314)
ln.Labour Freedom	16.461	0.182	-19.725
	(11.859)	(15.688)	(14.017)
Quality Math and Science edu.	-1.895	-3.273	-2.039
	(2.911)	(3.958)	(3.395)
Unemployment	-0.081	0.033	-0.115
	(0.599)	(0.819)	(0.711)
Constant	-466.117***	-594.976***	-343.075**
	(137.008)	(183.804)	(166.894)
Wald $\chi 2$	42.36	90.14	69.83
Prob $>\chi 2$	0.0001	0	0
Obs	336	336	336
Nr. Created	4256	11090	2278

Table 3.6: Panel data random effects regression analysis for the variable *Created*

3.7 Results Discussion and Interpretation

The results of the regression model were obtained using the Stata software. In table 3.6 there are the coefficients, the standard deviation in brackets and the level of significance of the variables inserted. For the sake of completeness, the value of the constant, the number of observations, the value of the sum of the dependent variable *Created* and the Wald $\chi 2$ and $\chi 2$ statistics have also been included. At first impact, what is more visible is that the variables contained in the entrepreneurial clusters are the ones that probably most influence the investment in AI companies, because they are statistically significant in all three models proposed.

Analyzing the entrepreneurial cluster in depth, among the factors that influence investment in new companies in AI, the crucial factors seem to be the number of patents applications in a country and the ease for an entrepreneur to start a new business as shown from the p-value of the variables *Patent Applications* and *ln.Starting a Business*. Patent applications are also a measure of the quality and motivation of entrepreneurs as in Gabrielsson, Politis, Dahlstrand (2013) and a business owner of patents is more likely to be financed as in Häussler, Harhoff, Mueller (2013)[65], Hoenig, Henkel (2015)[66]; an highly motivated entrepreneur facilitated by favorable market conditions is probably going to create a business. The coefficient of the two explanatory variables is positive, thus indicating a positive linear relationship between companies in AI, the number of patents and the ease of conducting a business. Still with regard to the two variables, however, it should be noted that the coefficient is positive and with a low standard deviation about the number of patents instead of very high and with a higher standard deviation about the ease of starting a business. In addition, the two variables are also poorly related to each other, their correlation coefficient is low and not very relevant in all three models proposed as indicated in table 3.8 and table 3.9.

Moreover, an important mention should be made to the *Ease of Access to Loans* in a country; what can be misleading is the presence of the negative sign in front of its coefficient for all the three analysis which should be translated as: the higher the probability of access to credit and the lower the number of startups that are financed. A possible interpretation of the negative sign has been extracted from figure 3.1. The cause could be related to the nature of the data collected and to understand it, we started from the top nine countries with the highest number of AI companies created in the period from 2007 to 2017; as shown in table 3.2, these nine countries alone account for just over 80% of all startups in the database with 4256 entities

(Model 1) while in Model 2 and 3 they account for about 70% of the total observations. In figure 3.1 in the grey column is shown the average value, per country for the years in which there were investments in AI, of the logarithm of the number of patents applications; this value is on average for these top countries above the general average and equal to 10 and its coefficient in the model is among the highest. In the same way the orange and red columns indicate for each country the average value of the variables *ln.Starting a Business* and *Ease Access to Loans*, values that are for the top nine country again above the average of the entire dataset. The natural logarithm of Starting a Business factor is on average equal to 4.5 but its coefficient is very high in all the three models proposed. The value of Ease of Access to Loans is on average 3.7 but has a negative coefficient. All three variables are not correlated by the table 3.8 and table 3.9 but the negative value of the Ease of Access to Loans coefficient can be seen as an attempt by the model to lower the dependent variable, the number of companies created when, by setting all the coefficients of the insignificant variables to zero, the other significant variables ln.Starting a Business and ln.Patent Applications coefficients are very high; moreover considered the fact that top nine countries weigh in the three scenarios between 70% and 80% of the total observations. In the same way the negative and high value of the constant can be interpreted.

Another possible, and maybe more correct, interpretation of the negative value is linked to the riskiness of the business; as the industry is still in its infancy, it is very difficult to obtain funding from banks as in Black, Strahan (2002)[79] and Banerjee, Breza, Duflo, Kinnan (2018)[80]; this can be translated as follows: although in a country there is a high degree of easy access to credit, the high uncertainty linked to the business does not allow access to funds and therefore to the creation of new AI startups.

From the value of the significance of the variable *Venture Capital Availability* it does not seem that the phenomenon of AI is very related to an high concentration of venture capitalist, the relationship is however positive but significant only in one of the three models. In a country that has a lot of investments in artificial intelligence is not linked to the fact that there are many and concentrated venture capital investors in it.

In the end, looking only at the statistical output data, the first hypothesis 3.3.1 made on the entrepreneurial cluster seems to be partly contested; artificial intelligence is not a business arising and financed mostly in areas where there is a high concentration of VCs and it does not depend in a positive linear way on the ease of access to credit towards banks; what is strongly

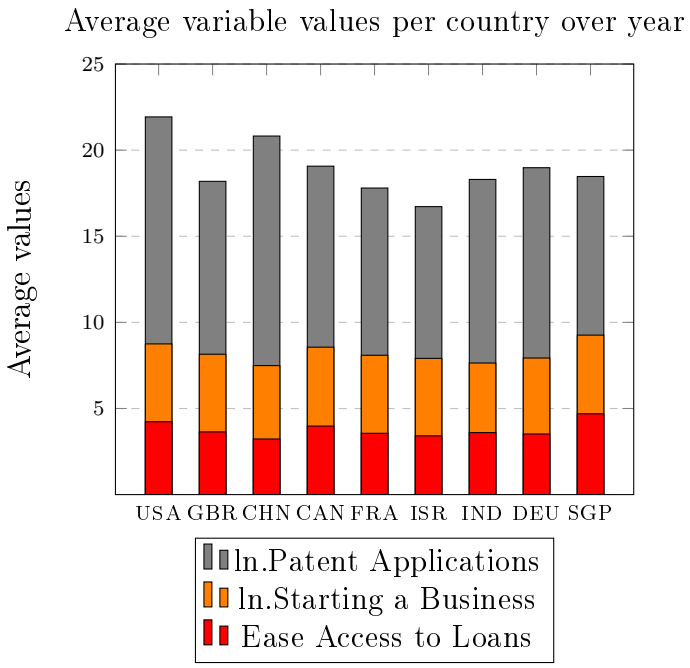

Figure 3.1: Average variable values per country per year for top nine AI countries (2007-2017)

binding instead is to own a patent and to be legally established in a country where it is easier to start a new business.

Going forward with the exploration of the various clusters, the second is the institutional one; the hypothesis identified in paragraph 3.3.2 started from the idea that in a country where there are favorable and supportive conditions by the government there are incentives for private investors to invest in AI. From the regression analysis the most significant variable of the cluster is *Intellectual Property Protection*. Its coefficient is positive and can be translated in this way: in a country where intellectual property is better protected, it is more likely that AI startups are created and financed; analyzing with an overview between statistical model and the type of business, that it has been seen that it is closely linked to the presence of patents, intellectual protection is the natural consequence; the parameter is therefore significant and explanatory. However, Intellectual protection in AI related companies has another task to protect what AI can create Gurkaynak, Yilmaz, Doygun, İnce (2018)[93] and DaCosta, Carrano (2017)[94] ; therefore a legislature that is quick to adapt its law to the market will generate a competitive advantage for the country in the immediate future.

Again in this cluster, only in the first model the *Human Freedom* and *Regulatory quality* indexes are significant; the two parameters are strongly related to each other as shown in table 3.8 and table 3.9, but also refer to the case in which the United States counts for half of the observations but, at the same time, the USA presents among the best values in the world for the two items so the result could be biased and is not completely correct the two variables to be taken into account as key drivers.

The second hypothesis held was partly correct; for an industry to develop it is necessary that there is protection by the state, in this case through the protection of intellectual property; however, the contribution that each state is giving to the development of the sector remains significant Ács, Audretsch, Braunerhjelm, Carlsson (2005)[84] and Raymond, St-Pierre (2010)[85], since at the beginning an industry needs to be supported, specially AI industry needs time, experience and high skilled professionals unless it will be able to be self-sufficient and mature. On the basis of this, it was expected that there would be a positive and significant coefficient for the variable *GDP in R%D* referring to government spending on research and development; the factor does not appear to be decisive in the area of AI but should be interpreted according to the time: only in the latest year governmental funding in AI has skyrocketed more or less from 2017 AI policies and plans arose in several country but the period taken in considerations by the analysis cover a time span before the intervention of the state.
On the other hand, explanatory variables concerning wealth *ln.GDP per capita* and taxation *ln.Tax Burden* in a country were not significant for the proliferation of artificial intelligence. The possibility of high taxation does not affect business and investments, in line with the results of Bruce, Mohsin (2006)[82] and Bruce, Liu, Murray (2015)[83], which in part testifies to the robustness of the results achieved; at the same time AI is not a business attached only to wealthy countries.

For the third and last cluster, the hypothesis made in paragraph 3.3.3 linked the presence of highly specialized workers to the creation and financing of artificial intelligence companies by VCs. In this regard, it was expected that the teaching of mathematics and science and the high presence of engineering faculties would be relevant to the model. In the results, the *Quality of Math and Science education* is not significant in any scenario but instead, the most important factor of the cluster *Engineering Universities x million* is significant only in Model 2, in the other two scenarios the p-value is still low but not relevant however the sign of the coefficient is positive; in this case we can consider Model 2 as the most reliable and close to reality, the

presence of numerous technical schools is somehow relevant for the birth of AI new business, high technical skills, that are difficult to acquire only with experience, are needed to create AI. As far as the other two variables *Unemployment* and *ln.Labour Freedom* were expected to be either significant or not null but they they actually aren't. Unemployment in this case is not a source of stimulation for the entrepreneurial spirit.

The fact that the variable related to the number of engineering universities is significant, gives reason to the hypothesis formulated above and is in line with the type of business that has been taken into consideration. In order to create and finance a startup in AI it is necessary that there are scientists able to control this technology and these professionals figures with these skills can only be trained within the engineering faculties or with specialist courses. Obviously a high number of engineering faculties does not guarantee a high quality of teaching or a high retention of talent, which is the real problem of this business, in the country where they are established; it makes sense the value of the variable and its positive coefficient, it is no coincidence that in the world we are witnessing a shortage of scientists and engineers specializing in this field.

At the end of this paragraph two tables about the correlation of independent variables are attached, table 3.8 valid for Model 1 and Model 2, table 3.9 valid for Model 3. In addition, table 3.7 is added which indicates for each country the total number of startups present in the database used.

3.8 Implications for Future Research

The artificial intelligence industry is very complex and broad, trying to reduce the explanation of the phenomenon to simple macroeconomic parameters may not be efficient or at least leave some significant aspects outside the discussion. A starting point for research in the future may undoubtedly be the source of the data. The Crunchbase database is very complete and rich in information but for a wider and more complete view of the whole world it may be interesting to use another data source to integrate with the one already existing from Crunchbase. Moreover, another relevant step could be the construction of a model based on a less unbalanced database, it could be useful to use a complete data set with all the historical data in all the years, even in the years where the number of new companies in AI funded was zero.

The estimates created by this model are, among other things, not very

precise; the values of the standard deviations and confidence intervals are exaggerated; one can take for granted the value of the significance of the variable and the sign of the constant but probably cannot exactly quantify what the effect of each single effect is. Certainly starting from the constructed database, with a different mathematical approach it could be possible to investigate in a deeper and more precise way rather than limit to a pure superficial analysis as done.

Moreover, no less relevant could be a research similar to the one done by Haddad, Hornuf (2018)[52] regarding the world of fintech and then transpose it to the world of AI: classify all the companies according to the type of AI they implement and propose an analysis model similar to the one done in this paper taking into account the number of companies created but classified by sector of use of AI and then evaluate the characteristics and drivers that are required for the proliferation of the different type of business.

One data that is missing in the available Crunchbase database is that which refers to the amount of money that is invested in each financing round, a data that could be useful to evaluate the amount of money that is useful for this industry in its various stages of growth. Remaining on the subject of missing data, a suggestion for future research may be the inclusion of an index built ad-hoc to assess the capacity of aggregated data concentration in a country and then integrate it into the model. Always on the same line of thought a suggestion could be about how to evaluate the investments made by companies in AI without the support of VC and in the same way to evaluate the quantity and quality of their research that are not patented; there are many firms not patenting AI, the value of this research is still unknown.

Finally, a fact that seemed misleading was the one that referred to the number of AI startup acquisitions in China over time: only one over ten years. The reason for this value could be due to a low accuracy of the data entered in the database used or it could be a suggestions as source of investigation for future research.

3.9 Conclusions and Personal thoughts

As we have seen, it seems that artificial intelligence, in order be developed and receive funding, needs active support from the government in the defense of intellectual property and patents that a company may possibly own, high ease of creation of a new business and wide access to funds as well as

to a highly skilled and experienced workforce. From the data owned the best places in the world where to start a business in AI are USA, China and United Kingdom, countries where there is a high concentration of startups in AI and where the added value that this technology can bring to economy and productivity has been understood long ago; in some cases the arise of new technology has been supported by government, in other cases the high tech environment created the basis for the natural growth of AI.

The future that is very near to us, the time span between 2020 and 2030, has all the prerequisites for significant changes to take place in every area of our lives thanks to the evolution of technology. The new technological paradigm shifts will happen much faster than those we have witnessed in the last ten years: if we only refer to the smartphone, the first iPhone was presented in 2007, but before the smartphones became widely used worldwide we had to wait until the end of the last decade. The problem with this first round of aggressive introduction of technology into our lives in this case has been the lack of infrastructure and the initial opposition to change due to the uncertainty about the use and effects of the new innovations at least in the beginning. This is no longer the case with AI. In this case, the world has already embraced the purpose of the innovation, is accustomed to technological change and infrastructures such as communication networks, large amounts of sensors and tracking technology devices are already widely spread all over the world and citizens are familiar with their use, including the most common such as smartphones, home automation appliances, self-driving cars and wearable technologies.

The changes will therefore be very fast, but everything we will need in the future is already there, the era of intelligent machines is coming and the race for its control is taking on a strategic dimension; in this case the prize up for the win at national level is the superiority that can come from technology and given the main competitors, the prize is very high and will be the title of world's first economy; it is no coincidence that the two main players are China and the United States; it is a competition in which the two players use completely different but both effective methods of approach: a strategy of central control and development by the Chinese government supported by the big local players and a strategy of development of artificial intelligence relocated to several research centers and mostly held in private hands in the USA.

Overall, the business world is just beginning to harness these technologies and their benefits. Most companies that have deployed AI in a specific func-

tion report achieving moderate or significant value from that use, but only few of them are embedding AI into multiple business units or functions. Indeed, many organizations still lack the fundamental practices to create value from AI at scale, mapping where their AI opportunities lie and having clear strategies for sourcing the data that AI requires. At this moment it is more fundamental than ever to have a clear strategy and to follow it, create the right culture into a company and the infrastructure in order to avoid being first movers in the market without clear objectives and knowledge, because the risk to see the economic effort not producing results is very high. Likewise, entering the world of AI too late can create a gap that is difficult to bridge compared to those who were able to control the technology earlier.

Beyond its ideological value, artificial intelligence will allow to benefit from numerous improvements in daily life, in the production sector and in the service sector; applications seem to be unlimited and is a field in continuous evolution and discovery, the technological future that awaits us will be focused on the support that technology can give to humanity and thus will be highly personalized on the needs of the user; the near future will be crucial for humanity because it will live a phase of transition in which technology will not only be a support tool but a complete integration with the human being. There will no longer be a coexistence but a relationship of symbiosis and synchronization will be created where the two worlds will be perfectly merged and humans will enhance their capabilities.

The relationship between man and machine is a topic of discussion that has widely fascinated men and literature but artificial intelligence has always been negatively represented in the public imagination; countless films have been shot, as many books have been written and numerous TV series have been created. Among the most important TV series that create very important insights and thought are Black Mirror[4] and Better Than Us[5]; of the negative vision, it is only necessary to obtain the main aspects and reflection points, but no one should be afraid to get closer to evolution; transitions time and uncertainty always scary people, this time the transition will happen so fast that there is no time to think and wait, only act and accept the revolution.

Obviously like every change that comes along it is necessary to identify its positive aspects but also its critical ones. The criticism in this case are high

[4]for further information visit: `https://www.netflix.com/it/title/70264888`
[5]for further information visit: `https://www.netflix.com/it-en/title/81026915`

because the changes that will be proposed will profoundly change the way things are done; in this regard without making big arguments or complex thoughts, one of the most immediate consequences to take into account is for example the large amount of manpower workers that may find themselves without a job and therefore will need a relocation that obviously will not be easy: the AI sector will create new jobs but they are not accessible to everyone, you need experience and skills that a common blue collar worker does not have or will not be able to learn easily.

In the same way, one of the actors that will have to pay great attention to the business evolution and be able to have great views on what the impact of AI could be will be the legislature officers; the legislature must take care to draw up guidelines for the sustainable development of this technology and not allow those who control it to create inequalities or injustices; it is important that the latter aspect is kept in mind by those who have control of the law and regulations in order to avoid going into the game regulation when the forces in the field are unbalanced towards AI owner/controller: prevention and proactivity are the keywords.

In conclusion, we, humans of the twenty-first century should consider ourselves very lucky; not everyone can claim of having lived in an era in which evolution has led to significant changes; in the past, revolutions have taken place through bloody wars and riots while today the approach is completely different, all it takes is one PC, an idea and anyone can change the world. It will be important not to be afraid and trust the change without forgetting the values that have distinguished human intelligence from animal one for millennia, in the hope of a better future and a more livable planet.

Country	Nr.Created	Country	Nr.Created
United States	1978	Turkey	8
Great Britain	434	Greece	8
China	246	Malaysia	7
Canada	172	Czech Republic	7
France	155	Iceland	7
Israel	150	Lithuania	6
India	143	Ukraine	6
Germany	135	New Zealand	6
Singapore	72	United Arab Emirates	5
Spain	71	Estonia	5
Netherland	57	Colombia	4
Austria	54	Egypt	4
Japan	45	South Africa	4
Sweden	45	Romania	3
Finland	38	Tunisia	3
Poland	35	Cyprus	3
Brazil	32	Vietnam	2
South Korea	30	Thailand	2
Denmark	28	Sri Lanka	2
Italy	25	Latvia	2
Switzerland	24	Slovakia	2
Portugal	24	Peru	2
Australia	24	Indonesia	2
Russia	23	Uruguay	1
Norway	22	Croatia	1
Hong Kong	20	Iran	1
Belgium	19	Philippines	1
Chile	11	Armenia	1
Hungary	10	Pakistan	1
Mexico	10	Serbia	1
Ireland	9	**Total**	**4256**
Argentina	8		

Table 3.7: Number of AI companies created per country (2007-2017); Crunchbase, 2020

	Ease Access to Loans	**ln.Patent Applicat.**	**ln.Start Business**	**Venture Capital Availab.**	**GDP in R%D**	**Human Freedom**	**Intellect. Property Protect.**
Ease Access to Loans	1						
ln.Patent Applications	0.0953	1					
ln.Starting a Business	0.3213	-0.2281	1				
Venture Capital Availability	0.8559	0.2084	0.3198	1			
GDP in R%D	0.2548	0.2892	0.2328	0.4043	1		
Human Freedom	0.2961	-0.152	0.5051	0.3396	0.4605	1	
Intellectual Property Protection	0.6542	0.0455	0.5507	0.6975	0.5747	0.6951	1
ln.GDP per capita	0.3536	-0.0289	0.6004	0.4238	0.6238	0.8045	0.7627
ln.Tax Burden	-0.1403	0.0076	-0.145	-0.2047	-0.4843	-0.4341	-0.4271
Regulatory Quality	0.4892	-0.0954	0.6113	0.5413	0.5315	0.8954	0.8392
Engineering Universities x million	0.1476	-0.462	0.4488	0.1996	0.1634	0.4474	0.3875
ln.Labour Freedom	0.3336	0.1467	0.2377	0.3472	0.1438	0.2199	0.3091
Quality Math and Science edu.	0.3217	-0.0606	0.3812	0.3032	0.2382	0.4286	0.4788
Unemployment	-0.3531	-0.278	-0.075	-0.3707	-0.2532	-0.0549	-0.2241

	ln.GDP per capita	**ln.Tax Burden**	**Regulat. Quality**	**Engin. Univer. x million**	**ln.Labour Freedom**	**Quality Math and Science**	**Unemplo.**
ln.GDP per capita	1						
ln.Tax Burden	-0.4921	1					
Regulatory Quality	0.8591	-0.3879	1				
Engineering Universities x million	0.4705	-0.1061	0.4643	1			
ln.Labour Freedom	0.2452	0.069	0.3636	0.1608	1		
Quality Math and Science edu.	0.4114	-0.0946	0.4726	0.3058	0.3437	1	
Unemployment	-0.1397	-0.0895	-0.1952	-0.0282	-0.3469	-0.3239	1

Table 3.8: Correlation matrix for Model 1 and Model 2

	Ease Access to Loans	**ln.Patent Applicati.**	**ln.Start Business**	**Venture Capital Availab.**	**GDP in R%D**	**Human Freedom**	**Intellect. Property Protect.**
Ease Access to Loans	1						
ln.Patent Applications	0.0451	1					
ln.Starting a Business	0.3135	-0.2868	1				
Venture Capital Availability	0.8554	0.1227	0.3068	1			
GDP in R%D	0.2365	0.246	0.2188	0.3793	1		
Human Freedom	0.2867	-0.2067	0.4994	0.3262	0.451	1	
Intellectual Property Protection	0.6509	0.0066	0.5461	0.7002	0.5684	0.6922	1
ln.GDP per capita	0.3414	-0.0922	0.5946	0.4052	0.6134	0.802	0.7605
ln.Tax Burden	-0.1454	0.0018	-0.1476	-0.2196	-0.4951	-0.4386	-0.4319
Regulatory Quality	0.4854	-0.1383	0.6078	0.5423	0.5259	0.8948	0.8383
Engineering Universities x million	0.148	-0.5016	0.4496	0.2046	0.1631	0.4485	0.3886
ln.Labour Freedom	0.3088	0.0363	0.2166	0.2877	0.0941	0.1963	0.292
Quality Math and Science edu.	0.321	-0.0714	0.3822	0.3104	0.2393	0.4299	0.4797
Unemployment	-0.3513	-0.2863	-0.0722	-0.3757	-0.2525	-0.0509	-0.2207

	ln.GDP per capita	**ln.Tax Burden**	**Regulat. Quality**	**Engin. Univer. x million**	**ln.Labour Freedom**	**Quality Math and Science**	**Unemplo.**
ln.GDP per capita	1						
ln.Tax Burden	-0.5008	1					
Regulatory Quality	0.8593	-0.3912	1				
Engineering Universities x million	0.4739	-0.1065	0.4649	1			
ln.Labour Freedom	0.2091	0.0672	0.3547	0.1641	1		
Quality Math and Science edu.	0.4144	-0.0945	0.473	0.3062	0.3585	1	
Unemployment	-0.1362	-0.0899	-0.1932	-0.0279	-0.3569	-0.3231	1

Table 3.9: Correlation matrix for Model 3

Bibliography

[1] Kai-Fu, Lee; 2019
AI Superpowers: China, Silicon Valley, and the New World Order Houghton Mifflin Harcourt, Boston, Massachusetts

[2] BBC News; August 8, 2016
Tesla car drives owner to hospital after he suffers pulmonary embolism http://www.bbc.co.uk/newsbeat/article/37009696/tesla-car-drives-owner-to-hospital-after-he-suffers\-pulmonary-embolism

[3] BBC News; July 1,2016
US opens investigation into Tesla after fatal crash https://www.bbc.com/news/technology-36680043

[4] Artificial General Intelligence conference; September 13, 2020
995 experts opinion: AGI / singularity by 2060 [2020 update] https://research.aimultiple.com/artificial-general-\intelligence-singularity-timing/

[5] Turing, A.M.; 1950
Computing Machinery and Intelligence. Mind, 59, 433-460 https://web.archive.org/web/20080702224846/http://loebner.net/Prizef/TuringArticle.html

[6] Polit, S.; 1984
R1 and Beyond: AI Technology Transfer at Digital Equipment Corporation. AI Magazine, 5(4), 76 https://doi.org/10.1609/aimag.v5i4.460

[7] BBC News; January 27, 2016
Google achieves AI 'breakthrough' by beating Go champion https://www.bbc.com/news/technology-35420579

[8] China Global Television Network CGTN; August 9, 2020
What is WeChat and what can it do https://newseu.cgtn.com/news/2020-08-09/What-is-WeChat-and-what-can-it-do--SNepY1rgNG/index.html

[9] Accenture research by Mark Purdy, Paul Daugherty; 2017
How AI boosts industry profits and innovation https://www.accenture.com/fr-fr/_acnmedia/36dc7f76eab444cab6a7f44017cc3997.pdf

[10] Il sole 24 Ore; September 4, 2020
A Torino la sede dell'I3A, istituto per l'intelligenza artificiale https://www.ilsole24ore.com/art/a-torino-sede-dell-i3a\-istituto-l-intelligenza-artificiale-AD8uaBn

[11] YouTube channel: Google Cloud; April 12, 2019
How Google's AutoML Vision helps AES fight climate change https://www.youtube.com/watch?v=lF-u7j1x0C0&ab_channel=GoogleCloud

[12] Google AI blog, August 13, 2019
Project Euphonia's Personalized Speech Recognition for Non-Standard Speech https://ai.googleblog.com/2019/08/project-euphonias-\personalized-speech.html

[13] McKinsey and Company; October 1, 2013
How retailers can keep up with consumers https://www.mckinsey.com/industries/retail/our-insights/how-retailers-can-keep-up-with-consumers#

[14] Raymond Perrault, Yoav Shoham, Erik Brynjolfsson, Jack Clark, John Etchemendy, Barbara Grosz, Terah Lyons, James Manyika, Saurabh Mishra, and Juan Carlos Niebles; December, 2019
The AI Index 2019 Annual Report AI Index Steering Committee, Human-Centered AI Institute, Stanford University, Stanford, CA; https://hai.stanford.edu/sites/default/files/ai_index_2019_report.pdf

[15] UPS Pressroom; 2020
ORION backgrounder https://www.pressroom.ups.com/pressroom/ContentDetailsViewer.page?ConceptType=Factsheets&id=1426321616277-282#:~:text=Results%20with%20ORION&text=Initial%20results%20show%20miles%20reduced,even%20on%20peak%20business%20days.

[16] Forbes; March 3, 2020
Transforming Drug Discovery Through Artificial Intelligence

https://www.forbes.com/sites/robertreiss/2020/03/03/transforming-drug-discovery-through-artificial-intelligence/#29aca6846a15

[17] CNN; April 30, 2020
Artificial Intelligence can't technically invent things, says patent office https://edition.cnn.com/2020/04/30/us/artificial-intelligence-inventing-patent-office-trnd/index.html

[18] Accenture Newsroom; November 14, 2019
Failure to Scale Artificial Intelligence Could Put 75% of Organizations Out of Business https://newsroom.accenture.com/news/failure-to-scale-artificial-intelligence-could-put-75-percent\-of-organizations-out-of-business-accenture-study-shows.htm#:~:text=NEW%20YORK%3B%20Nov.,Accenture%20(NYSE%3A%20ACN).

[19] L'Oréal Paris Beauty Trends
MakeUp Genius la nuova app per testare il trucco https://beautytrends.loreal-paris.it/senza-categoria/scopri-la-nuova-app-make-up-genius/

[20] McKinsey and Company; November 13, 2018
AI adoption advances, but foundational barriers remain https://www.mckinsey.com/featured-insights/artificial-intelligence/ai-adoption-advances-but-foundational-barriers-remain

[21] The state Council of the People's Republic of China; 2006
The National Medium- and Long-Term Program for Science and Technology Development (2006-2020) https://www.itu.int/en/ITU-D/Cybersecurity/Documents/National_Strategies_Repository/China_2006.pdf

[22] Cong Cao, Richard P. Suttmeier, Denis Fred Simon; December, 2006
China's 15-year Science and Technology Plan American Institute of Physics, S-0031-9228-0612-010-4

[23] China Briefing; July 25, 2012
China Releases 12th Five-Year Plan for National Strategic Emerging Industries https://www.china-briefing.com/news/china-releases-12th-five-year-plan-for-national-strategic\-emerging-industries/

[24] APCO worldwide; December 10, 2010; *China's 12th Five-Year Plan* http://www.export.gov.il/UploadFiles/03_2012/Chinas12thFive-YearPlan.pdf

[25] The State Council of PRC; October 12, 2017
China to invest big in 'Made in China 2025' strategy http://english.www.gov.cn/state_council/ministries/2017/10/12/content_281475904600274.htm

[26] Fang Jason, Wals Michael, ABC News; April 28, 2018
Made in China 2025: Beijing's manufacturing blueprint and why the world is concerned https://www.abc.net.au/news/2018-04-29/why-is-made-in-china-2025-making-people-angry/9702374

[27] BAAI; 2019
Beijing AI Principles https://www.baai.ac.cn/news/beijing-ai-principles-en.html

[28] Statcounter Globalstat; 2020
Search Engine Market Share in China - September 2020 https://gs.statcounter.com/search-engine-market-share/all/china

[29] Medium, Apollo Auto; September 3, 2020
Baidu Apollo Signs China's Largest Smart Transport Project in 2020; Company To Offer Robotaxi, Robobus Services in Guangzhou https://medium.com/apollo-auto/baidu-apollo-signs-chinas-\largest-smart-transport-project-in-2020-c0aebfd503b0

[30] Statista; 2020
Alibaba's cumulative active online buyers 2015-2020 https://www.statista.com/statistics/226927/alibaba-cumulative-active-online-buyers-taobao-tmall/

[31] The New York Times; October 26, 2020
Ant Group Set to Raise $34 Billion in World's Biggest I.P.O. https://www.nytimes.com/2020/10/26/technology/ant-group-ipo-valuation.html

[32] ABC net; July 31, 2020;
Leave no dark corner https://www.abc.net.au/news/2018-09-18/china-social-credit-a-model-citizen-in-a-digital-dictatorship/10200278?nw=0

[33] Forbes; June 4, 2018;
Artificial Intelligence In China: The Amazing Ways Tencent Is Driving It's Adoption https://www.forbes.com/sites/bernardmarr/2018/06/04/artificial-intelligence-ai-in-china-the-amazing-ways-tencent\-is-driving-its-adoption/?sh=45f09401479a

[34] Vox; November 2, 2018
Spend "frivolously" and be penalized under China's new social credit system https://www.vox.com/the-goods/2018/11/2/18057450/china-social-credit-score-spend-frivolously-video-games#:~:text=Every%20citizen%20starts%20off%20with,%2Dholder%20as%20%E2%80%9Cuntrustworthy.%E2%80%9D

[35] Business Insider; October 29, 2018
China has started ranking citizens with a creepy 'social credit' system — here's what you can do wrong, and the embarrassing, demeaning ways they can punish you https://www.businessinsider.com/china-social-credit-system-punishments-and-rewards-explained\-2018-4?IR=T

[36] BBC News; October 26, 2015
China social credit: Beijing sets up huge system https://www.bbc.com/news/world-asia-china-34592186

[37] Japanese Strategic Council for AI Technology; 2017
Artificial Intelligence Technology Strategy https://www.nedo.go.jp/content/100865202.pdf

[38] Government of UK; October 15, 2017
gGrowing the artificial intelligence in UK https://www.gov.uk/government/publications/growing-the-artificial-intelligence-industry-in-the-uk/executive-summary

[39] NS Tech; October 24, 2019
Ministers unveil 16 centers set to deliver 200m AI PhD programme https://tech.newstatesman.com/news/uk-ai-phd-programme

[40] France24; March 29, 2018
France to invest €1.5 billion in artificial intelligence by 2022 https://www.france24.com/en/20180329-france-invest-15-billion\-euros-artificial-intelligence-AI-technology-2022

[41] Techcrunch; MArch 29, 2018
France wants to become an artificial intelligence hub https://techcrunch.com/2018/03/29/france-wants-to-become-an\-artificial-intelligence-hub/

[42] Medium; May 16, 2018
South Korea Aims High on AI, Pumps $2 Billion Into R&D https://medium.com/syncedreview/south-korea-aims-high-on-ai-\pumps-2-billion-into-r-d-de8e5c0c8ac5

[43] Future of life institute;
AI Policy - Germany https://futureoflife.org/ai-policy-germany/

[44] Gruppo di esperti MISE; 2019
Proposte per una strategia italiana per l'intelligenza artificiale https://www.mise.gov.it/images/stories/documenti/Proposte-per-una-strategia-italiana-2019.pdf

[45] Ministero dello Sviluppo Economico; 2019
Strategia Nazionale per l'Intelligenza Artificiale https://www.mise.gov.it/images/stories/documenti/Strategia-Nazionale-Intelligenza-Artificiale-Bozza-\Consultazione.pdf

[46] Venture Scanner; 2019
Funding round count percentages in AI, cumulative data through March 2019

[47] Growthlist; 2020
The top 25 VC's investing in AI right now https://growthlist.co/blog/ai-vc

[48] CBInsights Research; 2020
The complete list of Unicorn Companies https://www.cbinsights.com/research-unicorn-companies

[49] Medium; February 14; 2019
Venture Capital Money is Massively Pouring into Silicon Valley & That's even Accelerating https://blog.exploratory.io/venture-capital-investing-happening-almost-entirely-in-\silicon-valley-c24834b2f45

[50] Technation; February 21, 2019
Venture capital investment in UK Artificial Intelligence startups increases almost six-fold in five years https://technation.io/wp-content/uploads/2019/02/TN-venture-capital-AI-1.pdf

[51] Cumming, Schwienbacher; July 18, 2018
Fintech Venture Capital Corporate Governance: An International Review

[52] Haddad, Hornuf; June, 2018
The emergence of the global fintech market: economic and technological determinants Small Business Economics 53(3)

[53] Gazel, Schwienbacher; January 19, 2020
Entrepreneurial fintech clusters Small Business Economics

[54] Kelly; October, 2012
Drivers of private equity investment activity: Are buyout and venture investors really so different? European Investment Fund, Venture Capital, 14:4, 309-330

[55] Madill, Haines, Riding; October 1; 2004
The role of Angels in Technology SMEs: a link to Venture Capital An International Journal of Entrepreneurial Finance Volume 7, 2005 - Issue 2

[56] Hirukawa, Ueda; October 11, 2018
Venture Capital and Innovation: which is first? Pacific Economic ReviewVolume 16, Issue 4

[57] Arvantis, Stucki; August 18, 2013
The impact of venture capital on the persistence of innovation activities of start-ups Small Business Economics; Volume 42, pages849–870(2014)

[58] Dushnitsky, Lenox; November, 2006
When does corporate venture capital investment create firm value? Journal of Business Venturing; Volume 21, Issue 6, November 2006, Pages 753-772

[59] Ni, Luan, Cao, Finlay; May 21, 2014
Can venture capital trigger innovation? New evidence from China International Journal of Technology Management (IJTM), Vol. 65, No. 1/2/3/4, 2014

[60] Darin, Penas; January 8, 2017
Venture capital and innovation strategies Industrial and Corporate Change, Volume 26, Issue 5, October 2017, Pages 781–800

[61] Davila, Foster, Gupta; November, 2003
Venture capital financing and the growth of startups firms Journal of Business Venturing; Volume 18, Issue 6, November 2003, Pages 689-708

[62] Manigart, Sapeinza; September 8, 2017
Venture Capital and Growth The Blackwell Handbook Of Entrepreneurship; Chapter 12

[63] Colombo, Grilli; November, 2010
On growth drivers of high-tech start-ups: Exploring the role of founders' human capital and venture capital Journal of Business Venturing; Volume 25, Issue 6, November 2010, Pages 610-626

[64] Colombo, Luukkonen, Mustar, Wright; September 21, 2010
Venture capital and high-tech start-ups International Journal of Entrepreneurial Finance;Volume 12, 2010 - Issue 4: Venture capital and high-tech start-ups

[65] Häussler, Harhoff, Mueller; March 28, 2013
To Be Financed or Not... - The Role of Patents for Venture Capital-Financing ZEW - Centre for European Economic Research Discussion Paper No. 09-003

[66] Hoenig, Henkel; June, 2015
Quality signals? The role of patents, alliances, and team experience in venture capital financing Research Policy; Volume 44, Issue 5, June 2015, Pages 1049-1064

[67] Agrawal, Gans, Goldfarb; September 13, 2017
The Impact of Artificial Intelligence on Innovation Toronto; Conference on Economics of Artificial Intelligence

[68] Agrawal, Gans, Goldfarb; 2019
Economic Policy for Artificial Intelligence National Bureau of Economic Research

[69] Calò; 2017
Artificial Intelligence Policy: A Primer Roadmap 51 C.D.L. Rev. 399 (2017-2018)

[70] Buiten; March 2019
Towards Intelligent Regulation of Artificial Intelligence Volume 10, Issue 1 (Symposium on Regulating the Risk of Disruptive Technology)

[71] Wilson, Daugherty, Morini-Bianzino; 2017
The Jobs That Artificial Intelligence Will Create MITSloan Management Review, Summer 2017 Issue

[72] Korinek, Stiglitz; December, 2017
Artificial Intelligence and Its Implications for Income Distribution and Unemployment The Economics of Artificial Intelligence: An Agenda, Agrawal, Gans, and Goldfarb. 2019

[73] Etzioni, Etzioni; March 7, 2017
Incorporating Ethics into Artificial Intelligence The Journal of Ethics volume 21, pages403–418(2017)

[74] Yu, Shen, Miao, Leung, Lesser, Yang; December 7, 2018
Building Ethics into Artificial Intelligence International Joint Conference on Artificial Intelligence (IJCAI'18), pp. 5527-5533, 2018

[75] Dignum; February 13, 2018
Ethics in artificial intelligence: introduction to the special issue Ethics and Information Technology volume 20, pages1–3(2018)

[76] Kuechle; June, 2014
Reginal concentration of entrepreneurial activities Journal of Economic Behavior & Organization; Volume 102, June 2014, Pages 59-73

[77] Samila, Sorenson; January 21, 2011
Venture Capital, Entrepreneurship, and Economic Growth Review of Economics and Statistics;Volume 93, Issue 1, February 2011 p.338-349

[78] Dubini; January 1989
The influence of motivations and environment on business start-ups: Some hints for public policies Journal of Business Venturing; Volume 4, Issue 1, January 1989, Pages 11-26

[79] Black, Strahan; December 17, 2002
Entrepreneurship and Bank Credit Availability The Journal of FinanceVolume 57, Issue 6

[80] Banerjee, Breza, Duflo, Kinnan; February 19, 2018
Do Credit Constraints Limit Entrepreneurship? Heterogeneity in the Returns to Microfinance Global Poverty Research Lab Working Paper No. 17-104

[81] Gabrielsson, Politis, Dahlstrand; June 25, 2013
Patents and entrepreneurship: the impact of opportunity, motivation and ability International Journal of Entrepreneurship and Small Business; Volume 19, Issue 2

[82] Bruce, Mohsin; June, 2006
Tax Policy and Entrepreneurship: New Time Series Evidence Small Business Economics volume 26, pages409–425(2006)

[83] Bruce, Liu, Murray; September, 2015
State tax policy and entrepreneurship National Tax Journal, suppl. Special Issue; Washington Vol. 68, Iss. 3S, Sep 2015

[84] Ács, Audretsch, Braunerhjelm, Carlsson; 2005
Growth and Entrepreneurship: An Empirial Assessment Papers on Entrepreneurship, Growth and Public Policy 3205

[85] Raymond, St-Pierre; January, 2010
R&D as a determinant of innovation in manufacturing SMEs: An attempt at empirical clarification Technovation; Volume 30, Issue 1, January 2010, Pages 48-56

[86] Acs, Audretsch, Braunerhjelm, Carlsson; February 15, 2011
Growth and entrepreneurship Small Business Economics volume 39, pages289–300(2012)

[87] Yartey; February 2008
The Determinants of Stock Market Development in Emerging Economies: Is South Africa Different? IMF Working Paper, February 2008

[88] Bailey,Thomas; October 25, 2017
Regulating away competition: the effect of regulation on entrepreneurship and employment Journal of Regulatory Economics volume 52, pages237–254(2017)

[89] Klapper, Leaven, Rajan; December, 2006
Entry regulation as a barrier to entrepreneurship Journal of Financial Economics; Volume 82, Issue 3, December 2006, Pages 591-629

[90] Jadhav; 2012
Determinants of foreign direct investment in BRICS economies: Analysis of economic, institutional and political factor Procedia - Social and Behavioral Sciences; Volume 37, 2012, Pages 5-14

[91] Jalilian, Kirkpatrick, Parker; January, 2007
The Impact of Regulation on Economic Growth in Developing Countries: A Cross-Country Analysis World Development; Volume 35, Issue 1, January 2007, Pages 87-103

[92] Davies; December, 2011
An evolutionary step in intellectual property rights – Artificial intelligence and intellectual property Computer Law & Security Review; Volume 27, Issue 6, December 2011, Pages 601-619

[93] Gurkaynak, Yilmaz, Doygun, İnce; December 23, 2018
Questions of Intellectual Property in the Artificial Intelligence Realm The Robotics Law Journal, Volume 3, No. 2, pp.9-11

[94] DaCosta, Carrano; August 30; 2017
Intellectual Property Protection for Artificial Intelligence Westlaw Journal Intellectual Property

[95] Jin; January, 2018
Artificial Intelligence and Consumer Privacy The Economics of Artificial Intelligence: An Agenda, Agrawal, Gans, and Goldfarb. 2019

[96] Manheim, Kaplan; December 13, 2019
Artificial Intelligence: Risks to Privacy and Democracy 21 Yale Journal of Law and Technology 106 (2019)

[97] Cowling, Bygrave; March 24, 2011
Entrepreneurship and Unemployment: Relationships between Unemployment and Entrepreneurship in 37 Nations Participating in the Global Entrepreneurship Monitor (GEM) 2002 Babson College, Babson Kauffman Entrepreneurship Research Conference (BKERC), 2002-2006

[98] Chidiebere, Iloanya, Udunze; December 2014
Youth unemployment and entrepreneurship development: challenges and prospects in Nigeria Kuwait chapter of Arabian Journal of Business and Management review; Vol. 4, No.4; December, 2014

[99] Ravishankar, Pan, Myers; May 10, 2012
Information technology offshoring in India: a postcolonial perspective European Journal of Information Systems; Volume 22, 2013 - Issue 4

[100] Todd, Javalgi; 2007
Internationalization of SMEs in India: Fostering entrepreneurship by leveraging information technology International Journal of Emerging Markets, Volume 2, Number 2, 2007, pp. 166-180(15)

[101] Cumming, Walz, Werth; October 3, 2016
Entrepreneurial Spawning: Experience, Education, and Exit Financial Review; Volume 51, Issue 4

[102] Crunchbase database; September 10, 2019
UK Artificial Intelligence Investment Reaches Record Levels `https://about.crunchbase.com/blog/uk-artificial-intelligence-investment-reaches-record-levels/`

[103] Laird, Ware; December, 1982
Random-Effects Models for Longitudinal Data International Biometric Society; Vol. 38, No. 4 (Dec., 1982), pp. 963-974 (12 pages)

[104] Hedeker, Gibbons; December, 1994
A Random-Effects Ordinal Regression Model for Multilevel Analysis International Biometric Society; Vol. 50, No. 4 (Dec., 1994), pp. 933-944 (12 pages)