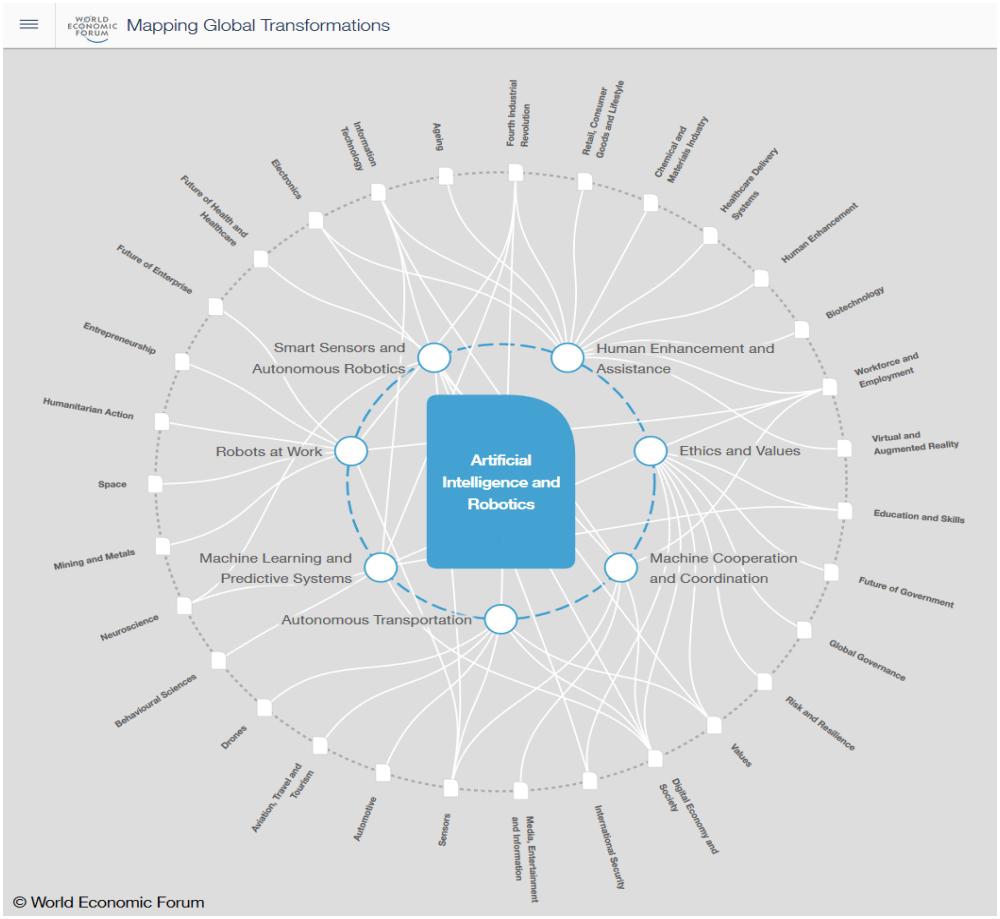
The Artificial Intelligence system in the USA

Master Thesis



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Summary

This thesis explores and analyses the Artificial Intelligence (AI) system in the Unites States of America. The purpose of the thesis is to depict the dynamics of the AI system in the USA and how it has evolved into its current state. The portrayal of the system will contribute into comprehending the causes and the effects of the phenomenon of the privatization of AI research. Finally, the role of the university in the changing AI system is discussed.

The term Artificial Intelligence is described and examples of the main applications in various sectors are provided. AI software and algorithms have been incorporated in many products and are used by millions of people daily.

The Triple Helix (TH) model is used to depict the interactions and the network of relations between the three institutional spheres of the government, academia and the industry. Reference is also made to the BIG DATA which are a vital component in the AI system.

The TH framework is used as a basis for the analysis of the phenomenon of the privatisation of research and its implications for the university and the economy. In the end, the role of the university through its three missions is presented and how it could contribute in the changing AI system for the preparation of the society and the economy so as to benefit from the new AI era.

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1. Introduction

One of the most frequent discussion issues lately in the news has been the applications of AI and their future implications for society and the economy. On one hand, there have been warnings from accomplished scientists such as Stephen Hawking and entrepreneurs such as Elon Musk and Bill Gates about the dangers that AI could pose to humanity. On the other hand, there have been reports about the contributions of AI in many sectors, one of which is the health sector and its contribution towards relieving employees from tedious and repetitive tasks.

The purpose of the paper is to explore what is AI and what is not. Will be described the history of the AI field, the main current applications of AI and the sectors of economy that they affect. The AGI (artificial General Intelligence) is the main aspect of AI that causes the most concern. By putting AI in its proper dimensions, one could distinguish whether the fears expressed are justified or not and up to which point.

Analysis of the AI field in the USA will take place in order to decipher the facts that have led to the current state of AI. Given the highly transformative and disruptive effect of AI, it is important to see which are the main formative powers in the country that is leading the AI race. Understanding the economic, social, political and regulatory framework in the USA, one gets a sense of direction about the future of the field. The analysis is performed though the Triple Helix model (TH).

The result of the analysis concludes to the fact that the AI field is highly concentrated to a few firms, the sector is mostly unregulated and the AI research has become privatized. The hegemony of private firms in AI research, a field that belongs traditionally to the academia will be examined in depth.

Given the importance of AI for society and the economy, the university needs to step up and press the government to undertake regulatory steps to promote openness and fairness in AI applications.

The contribution of this paper consists in providing an as accurate as possible picture of the important AI field. The TH model presented here can serve as a basis for the comprehension and analysis of many current issues relating to AI. The scandals that will be described later can be discussed and the reasons be comprehended using the specific framework. In addition, the crucial issue of the privatization of AI research is being analysed and put into perspective. Finally, the vital role of the university through its three missions will

be delineated. The academia needs to take a stand, educate the people, mobilize the government and work effectively with industry in order to navigate through the effortful times that are ahead.

1.1 Research question

1. How is the AI system in the US economy and what factors have led it to its current form?
2. Analysis of the phenomenon of the privatization of research:
    a. What are the implications of the privatization of research for the university and the society?
    b. What should be the role of the university in the changing AI system now and in the future?

2. Methodology

This chapter introduces the methodology followed in this paper.

The purpose of this paper is to examine the AI applications that affect a vast array of human activity today through the lenses of a system. We will mainly describe the USA model since it has been in the forefront of AI research for many years. The access to primary and secondary data is facilitated by the fact that they are written in English and many are open to the public. The AI research has been taking place for decades. However, the rise of social media and the impressing improvement of computers' power the last years has led to an unprecedented development of AI and its deployment in many applications from Google search algorithms to banking bot agents and advanced medical diagnosis/treatment software. The system consists of the industry, academia and the government, also known as the Triple helix model. Specific reference will be made to BIG DATA, which are crucial to the training of AI and have direct implications for the society and the economy.

The systems view will be used. This paper is both descriptive and explanatory.

From epistemological aspect, according to Easterby-Smith et al[1] (2015) the systems theory could more easily be classified towards the engaged positivism approach. However, since this paper will analyse human and organisational relations, it could be placed a bit closer to the constructionism end of the axis. A research approach of qualitative method will be used. Qualitative research will be used to highlight the theory as well as the relations between the three helixes and the analysis of the research questions. Quantitative data will be used to illustrate better specific aspects of the issue described each time.

It has been a multifaceted thesis that required the use of extensive bibliography. The majority of the articles used were from peer reviewed journals. However, AI research field has been developing frantically the last years. Many articles used were published within the last two years and some even just the previous month. In order to keep up with the continuously updated literature, some of the articles are not peer reviewed. Articles from the internet and various magazines such as the Economist, WSJ, NYT and tech websites were deployed to reference the latest developments and cases that took place. Data from various governmental agencies of the USA were also used in order to present governmental facts and figures in various issues.

[1]Mark Easterby-Smith, Richard Thorpe, Paul Jackson (2015) Management and Business Research, 5th Edition, Sage Publications

First will be presented the framework and then the privatization of research phenomenon will be analyzed. The perspective of the academia and how the university could contribute in the changing AI system will be discussed at the last part of the thesis.

Limitations

The AI field is developing rapidly. By the time this thesis is finished new inventions will have taken place. Thus, most probably the latest news about the field are not incorporated. For the same reason, articles that have been used that are not all peer reviewed as they were written only a few months ago to depict the current developments. The AI field is international, however due to size constraints the analysis is restricted mostly to the description of the USA market.

3. Theoretical Framework

In this chapter will be discussed the theoretical framework used in the thesis. The Triple Helix model was chosen to analyse and explain the system of Artificial Intelligence in the USA, because it takes into consideration not a linear but an interactive model of innovation and applies in a knowledge intensive economy, which is exactly the case in the AI field.

In addition, the TH is flexible and abstract which allows its use in many sectors. It is ideal to describe the relations between the three institutions (government, university and industry) and how they change and evolve through time. A TH is not anticipated to be stable (Etzkowitz and Leydesdorff, 2000a) but to "*remain in transition*". The helixes interact with each other through various networks and their relations and ways of communications change dynamically. Moreover, the TH model also indicates (Etzkowitz and Leydesdorff, 2000 a) the changes that take place within the institutions, internally, and how they transform over time. The alterations in the roles of the three institutions of the AI system and the shift in their dynamics will be described below.

Furthermore, the TH denotes the enhanced role that the university plays in the system through its transformation. The importance of the university is shared and will be explored in the last chapters.

3.1 The Triple Helix (TH) model

The triple helix (TH) model (Etzkowitz and Leydesdorff 1995) was developed to explore the interaction between three institutions, academia, industry and government in a knowledge-based economy. The knowledge-based economy is a term used to describe economies that are "*directly based on the production, distribution and use of knowledge and information*" (OECD, 1996[2]). This manifests through the tendency of OECD countries to invest heavily in high technology industries and labour. The distribution of knowledge takes place through formal and informal networks/channels and is vital to the performance of economies. According to OECD (1996), innovation is led by producers and users that interact by exchanging both forms of knowledge, tacit and codified.

[2]Organization for Economic Co-operation and Development, 1996, "The Knowledge-Based Economy", p. 7

The Triple Helix Model of innovation is utilized by policy makers, in both national and international levels, to design policies that promote innovation. According to Ranga and Etzkowitz (2013) the TH can be used as an analytical construct for both simple as well as complex contexts. TH offers a wider perspective into comprehending the source and growth of innovation in the economy and depicts the transition from the Industrial economy, which was dominated by the interaction between the government and the industry, to the Knowledge Economy. The latter distinguishes due to the upgraded role for the University as institution as well as the dynamic and hybrid interactions between the three main spheres (university, government, industry).

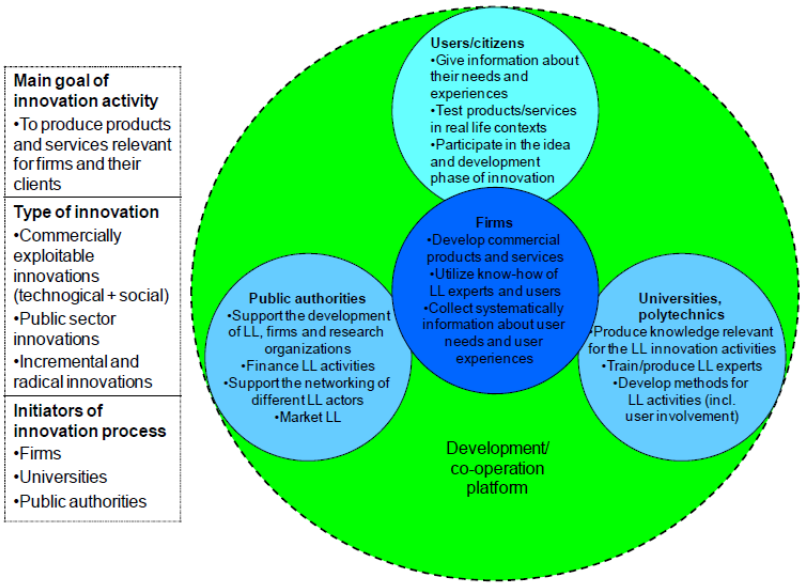
Etzkowitz et al. (2000 b) discuss the emergence of the entrepreneurial university which encloses its "third mission". They highlight the increasing significance of the university as a key knowledge- producing actor in the knowledge-based economy.

Weiai Wayne XU, In Ho Cho and Han Woo Park (2016) argue that knowledge has become progressively more crowd-sourced as people, groups and various organizations are networking via social media. They comment that the TH is an early application of a network perspective of the collaborations between the three main spheres, which network however becomes progressively more complex through the active participation of citizens.

McAdam and Debackere (2018) posit that the effectiveness of TH has been debated due to the failure of regions in achieving the anticipated innovation levels, employment and national product growth. The need to address the challenges of regional innovation policies, led eventually to the development of the Quadruple Helix model. This model (Carayannis et al 2012b) has incorporated the public as a fourth helix. Carayannis and Campbell (2009, 2010, 2012a) introduced the Quadruple and later Quintuple Innovation Helix model. The Quadruple model highlights the importance of incorporating the "civil society" and the "media- and culture –based public" into the innovation system; builds on the integration of democracy in the model of innovation.

Arnkil et al (2010) make a different approach to the QH model presenting it as a continuum or space, where many alternate HQ models thrive. They described four ideal models, without excluding other real forms and demonstrated the different roles that the government can undertake to assist the interaction between the helixes as enabler, decision maker, supporter, utilizer, marketer and quality controller. Arnkil et al proposed the firm –centered living lab which is depicted in the graph no 1.

Graph 1: The firm-centred living lab model



Source: ***Robert Arnkil, Anu Järvensivu, Pasi Koski, Tatu Piirainen (2010) Exploring Quadruple Helix. Outlining user-oriented innovation models. Työraportteja 85/2010 Working Papers. University of Tampere, Institute for Social Research*****, p. 68**

The graph provides a nice visual representation and a short description of the various roles that the different actors of any system play, even though the firm may not always be the connecting link as depicted here.

M. Scoric (2013) concludes that the implications of big data will call for an extension of the TH towards the Quadruple innovation model, which will include “non-market actors”.

The Big Data play an important role in the training and rapid progress of AI algorithms. The culture of social media (e.g. Facebook, Twitter, Instagram) and the massive use of smart phones has offered an abundance of data that have been utilized by the private sector and the government for reasons of marketing, surveillance, behavior control and alteration, machine learning etc.

Yan Yang et al (2012) adjusted the TH model to Quadruple model in order to examine the processes of eco-innovation.

Conclusion

The TH helix is a flexible model that can be adjusted by adding more helixes in order to describe various systems. For example, the development of the Quadruple model the last years has offered interesting perspectives. Miller et al[3] (2017) posit that the research regarding the Quadruple Helix model is in its infantry and "*is fragmented and lacks coherent frameworks and conceptualisations which fully depict the dynamic and evolving nature of UTT*". According to Parveen et al (2015) the Quantruple Helix model is not well defined nor well established in innovation research. However, there are many models that each insert a different actor as the fourth helix in the model.

Leydersdorff (2012) argues that the metaphor that is used by the TH model allows for its extension to more helixes. However, he proposes that the extension of the model should take place one step at a time and as required to strengthen its explanative power.

In this context, the well-established Triple Helix Model will be used to analyse the relations between the three institutional spheres: University, Industry and Government. However, reference will also be made to the BIG DATA and how they have affected the AI sector. The BIG DATA represent a vital component for the comprehension of the AI TH system in the USA. The misuse of BIG DATA by AI applications in several instances has caused disturbances to actors of the model.

The TH analysis will provide the framework that will explain how the privatisation of research resulted. But first there will a discussion about what AI is.

[3]Kristel Miller, Rodney McAdam and Maura McAdam (2016), "A systematic literature review of university technology transfer from a quadruple helix perspective: toward a research agenda", R&D Management 48, 1, 2018, p. 7.

4. Artificial Intelligence (AI)

This chapter will delineate the meaning of the term AI, the basic applications of AI, the economic sectors affected. AI is very important because it is expected to affect virtually all areas of human life. In addition, the prospects of the growing AI market will be described. AI technologies have entered the economy and the revenues are expected to grow exponentially. Finally, there will be reference to cases where the use of AI technologies have failed and the reasons that it caused so much concern. Many known personalities like Stephen Hawking, Elon Musk and Sergey Brin[4] have raised awareness concerning the dangers that AI could cause to the society.

4.1 Artificial Intelligence definition

The term artificial intelligence[5] was first used by John McCarthy in 1955 in a proposal for the purposes of organising a research workshop at Dartmouth College in Hannover, USA about the subject in 1956. It is a rather young science field.

There is no single definition of AI. For explanatory purposes two definitions will be presented one by the first user of the term and one by the US government, since the American AI system will be analysed further.

According to John McCarthy (2007) artificial intelligence is "*the science[6] and engineering of making intelligent machines, especially intelligent computer programs. It is related to the similar task of using computers to understand human intelligence, but AI does not have to confine itself to methods that are biologically observable*.

According to a US agency report[7]:

[4]Sam Shead (28/4/2018). Google Billionaire Sergey Brin Urges Caution On AI Development. https://www.forbes.com/sites/samshead/2018/04/28/google-billionaire-sergey-brin-urges-caution-on-ai-development/#45978dc026a7 accessed 1/5/2018 and The economist (9/5/2015), The dawn of artificial intelligence. https://www.economist.com/news/leaders/21650543-powerful-computers-will-reshape-humanitys-future-how-ensure-promise-outweighs accessed 1/5/2018

[5] Stuart Russell and Peter Novig (2003). Artificial intelligence : a modern approach . 2nd edition. Pages 17-18

[6]John McCarthy (2007), "What is artificial intelligence?" Stanford University. http://jmc.stanford.edu/articles/whatisai/whatisai.pdf. page 3.

[7] ANON (1994), Critical technology assessment on the US artificial intelligence sector, Technical Report PB93-192409, US department of Commerce. Page vi.

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"*AI refers to highly engineered computer software programs used to make computers do things that appear intelligent- such as reason, learn, create, understand human speech, or solve problem. As a science, AI studies the nature of intelligence, and tries to make computers simulate intelligent behaviour*".

According to the authors[8] of the "100 year study on AI", the exact lack of a precise definition has benefited AI greatly by allowing it to flourish in all directions.

4.2 Main applications of AI

Many people think of Terminator[9] when asked about AI, without realizing that they use AI applications daily. There are various types of AI which will be analysed briefly. There is a distinction (Deloitte[10] 2016) between Artificial Narrow Intelligence (ANI) and Artificial General Intelligence (AGI). ANI, also known as weak AI, is the prevailing form of AI today and performs limited and specialized tasks. According to Deloitte (2016) "*ANI is capable[11] of carrying out specific tasks brilliantly, using a combination of advanced algorithms, deep learning[12] and various other techniques depending on the use. Often, Natural Language processing is employed to facilitate human interaction*". Examples of ANI are based on machine learning[13] and its various applications.

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[8] Peter Stone, Rodney Brooks, Erik Brynjolfsson, Ryan Calo, Oren Etzioni, Greg Hager, Julia Hirschberg, Shivaram Kalyanakrishnan, Ece Kamar, Sarit Kraus, Kevin Leyton-Brown, David Parkes, William Press, AnnaLee Saxenian, Julie Shah, Milind Tambe, and Astro Teller. "Artificial Intelligence and Life in 2030." One Hundred Year Study on Artificial Intelligence: Report of the 2015-2016 Study Panel, Stanford University, Stanford, CA, September 2016. Doc: http://ai100.stanford.edu/2016-report.

[9] https://en.wikipedia.org/wiki/The_Terminator accessed 31/5/2018

[10] Deloitte (2016), Artificial Intelligence Innovation Report, https://www2.deloitte.com/content/dam/Deloitte/at/Documents/human-capital/artificial-intelligence-innovation-report.pdf

[11] Deloitte (2016), Artificial Intelligence Innovation Report 2016, https://www2.deloitte.com/content/dam/Deloitte/at/Documents/human-capital/artificial-intelligence-innovation-report.pdf, page 3

[12] For definitions of the terms see Yann LeCun and Yoshua Bengio and Geoffrey Hinton (2015), "Deep learning", Nature volume 521, pages 436–444. In page 436 is mentioned that "*Deep-learning methods are representation-learning methods with multiple levels of representation, obtained by composing simple but non-linear modules that each transform the representation at one level (starting with the raw input) into a representation at a higher, slightly more abstract level. With the composition of enough such transformations, very complex functions can be learned*." See also Pedro Domingos (2015). The master algorithm : how the quest for the ultimate learning machine will remake our world. Penguin Books, page 1: "*An algorithm is a sequence of instructions telling a computer what to do*".

[13] According to the World Economic Forum(WEF) Global Future Council on Human Rights 2016-18, (2018) White Paper How to Prevent discrimatory outcomes in Machine Learning. World Economic Forum, page 16, the following definition is provided. "*A machine learning (ML) model is one that leverages computer programs that automatically improve with experience and more data*". See also the report CBInsights (2018), "The Top AI trends to watch in 2018". CBInsights, page 3 where it defines that "*Machine learning refers to the training of algorithms on large data sets so that they learn how to identify and generate desired patterns. Over time, the algorithms — provided with the correct parameters by their human creators — get better at their tasks*".

AGI, also known as strong AI, would be able to perform a wide variety of tasks like a human. AGI has not been invented yet.

Most common applications of AI

The current applications of AI, that are being daily used by millions of users, include the following:

Play games: AI was used to win human champions in the games of chess and GO. In 2017 Deepmind, a company researching AI that is owned by Google, created the program AlphaZero[14], which taught itself to play chess and Go within a day and managed to win the respective best playing programs.

Speech recognition: Widely used digital personal[15] assistants like Siri in Apple products, Alexa from Amazon and Cortana in Microsoft use AI technologies to understand, process human oral requests and reply to them.

Google search engine: the company[16] is using machine learning program RankBrain to improve the results of Google Search engine.

Facebook recommendations: The application recognizes[17] the faces of friends in photos and suggests to the user to tag them accordingly.

Amazon recommendations: The company has been using AI applications (machine learning) to improve the recommendations[18] provided to customers regarding products that might interest them.

[14] David Silver, Thomas Hubert, Julian Schrittwieser, Ioannis Antonoglou, Matthew Lai, Arthur Guez, Marc Lanctot, Laurent Sifre, Dharshan Kumaran, Thore Graepel, Timothy Lillicrap, Karen Simonyan, Demis Hassabis (5/12/2017), Mastering Chess and Shogi by Self-Play with a General Reinforcement Learning Algorithm https://arxiv.org/abs/1712.01815 accessed 30/5/2018 and Richard Waters (12/1/2018), Techmate: How AI rewrote the rules of chess. https://www.ft.com/content/ea707a24-f6b7-11e7-8715-e94187b3017e accessed 30/5/2018

[15] https://www.economist.com/technology-quarterly/2017-05-01/language accessed 30/5/2018

[16] Sam Shead (28/4/2018). Google Billionaire Sergey Brin Urges Caution On AI Development https://www.forbes.com/sites/jaysondemers/2015/11/12/what-is-google-rankbrain-and-why-does-it-matter/#414b75e5536b accessed 30/5/2018

[17] Erik Brynjolfsson and Andrew McAfee (2017), Business of Artificial Intelligence. What it can — and cannot — do for your organization https://hbr.org/cover-story/2017/07/the-business-of-artificial-intelligence accessed 30/5/2018

[18] Erik Brynjolfsson and Andrew McAfee (2017), Business of Artificial Intelligence. What it can — and cannot — do for your organization. https://hbr.org/cover-story/2017/07/the-business-of-artificial-intelligence accessed 30/5/2018

Examples of sectors that AI affects

AI technology has been disruptive in the economy. The US NSTC[19] (2016) AI R&D strategic plan refers to the following areas that will benefit from use of AI technologies: manufacturing, logistics, finance, transportation, agriculture, marketing, communications, education, law, medicine, security and law enforcement etc. To illustrate the importance of AI, examples of its applications to select few domains will be presented.

Manufacturing: According to US NSTC (2016) AI R&D strategic plan, AI technologies could lead to vast improvements in manufacturing such as advanced inventory related processes, decrease production costs, provide accurate estimations of demand etc. CB Insights 2018 it its report on "The top AI trends to watch in 2018" presents the example of a Chinese company that will be making apparel for the company Adidas while replacing workers with sewing industrial robots. People will be used in administrative posts as well as for the service of the robots and their operation. This is one example of the transformative effect of AI in production.

Transportation: The US NSTC report on strategic AI R&D plan discusses the contribution of AI towards ensuring structural health, providing travellers with real time information about their chosen routes etc. The "100 year study on AI" report highlights the transforming effect of the use of self-driving cars, which have already started making their appearance in the streets. The report presents the use of AI by various cities so as to optimize the schedules of busses and metro to better serve the real demands of the public based on traffic data.

Uber and similar[20] services (based on-demand) benefit from AI technology through the use of dynamic ricing and algorithms combining drivers with clients.

Healthcare: The AI applications on the health sector have attracted the interest of many actors. The "100 year study on AI" argues that the Health-related AI applications that utilize data analytics have been limited so far due to regulatory issues such as standards for the protection of patient's privacy, lack of adequate digitalization of health archives etc. Accenture (2017) has identified the following top AI applications in the health sector among which are: "*robot assigned*[21] *surgery, Virtual nursing assistants, administrative workflow*

[19] NSTC, Networking and Information Technology Research and Development Subcommittee (2016), The national artificial intelligence research and development strategic plan, Office of Science and Technology Policy

[20] Peter Stone, Rodney Brooks, Erik Brynjolfsson, Ryan Calo, Oren Etzioni, Greg Hager, Julia Hirschberg, Shivaram Kalyanakrishnan, Ece Kamar, Sarit Kraus, Kevin Leyton-Brown, David Parkes, William Press, AnnaLee Saxenian, Julie Shah, Milind Tambe, and Astro Teller. "Artificial Intelligence and Life in 2030." One Hundred Year Study on Artificial Intelligence: Report of the 2015-2016 Study Panel, Stanford University, Stanford, CA, September 2016. Doc: http://ai100.stanford.edu/2016-report. page 23

[21] Accenture (2017).Artificial Intelligence: Healthcare's new nervous system", page 3

assistance, Fraud detection, Dosage Error Reduction, etc". The US NSTC report refers to the use of AI applications to reduce considerably the error rates in pathologists' diagnosis of patients.

The few examples mentioned above illustrate the increasing impact that AI is having and is expected to have in many aspects of daily life.

4.3 Size of the AI Market and contribution to companies' profits

The importance of the AI technologies and their implications on the economy become better understood when examining the size of the market in numbers.

CBinsights (2018) in its report for "the state of AI 2018" explains that machine learning has been incorporated in virtually all significant software programs.

Purdy and Daugherty (2017a)[22] identify three ways through which AI will boost the economy. The first one is through the intelligent automation, which is a term used to describe the use of systems that merge AI with automation and will lead to high efficiency. E.g. the data from automated procedures could be gathered, analysed by AI and course of actions could be proposed. Secondly AI will assist and boost the skills and performance of the workforce. For example, low value adding tasks could be undertaken by AI, whereas AI will facilitate workers in performing their more demanding tasks by identifying patterns and providing valuable information from a combination of data sources. And last, AI will facilitate innovation by shortening the creation and production cycles of new products/services.

According to Purdy and Daugherty[23] (2017b) AI will increase the labor productivity by 40% in the US by 2035.

IDC[24] predicted that in 2018 the global spending on cognitive and AI systems will reach the amount of 19.1 billion dollars, which will correspond to a 54,2 % rise compared to 2017. The USA are expected to account for three quarters of this spending, guided by the banks and retail industry.

[22] Mark Purdy and Paul Daugherty (2017a). How AI boosts industry profits and innovation. Accenture. Pages 13-15
[23] Mark Purdy and Paul Daugherty (2017b). Why Artificial Intelligence is the future of growth. Accenture. Pages 13-15
[24] IDC (22/3/2018). Worldwide Spending on Cognitive and Artificial Intelligence Systems Will Grow to $19.1 Billion in 2018, According to New IDC Spending Guide. https://www.idc.com/getdoc.jsp?containerId=prUS43662418 accessed 20/4/2018 . IDC stands for International Data Corporation.

Tractica estimated that the world revenue[25] that is expected to flow from AI software will sky rocket from 3,2 billion USD in 2016 to almost 90 billion USD by 2025. The company estimates that the corporate sector will embrace and use AI technologies more intensely in the following years.

4.4 Risks and main concerns regarding AI

The applications of AI apart from hope and expectations for the future have also caused considerable concerns for a number of issues. Some of the reasons for these concerns will be analysed below.

Bad examples so far

There have been distinctive examples in the past where the use of algorithms and Big Data have led to detrimental effects in society. The WEF[26] published a White Paper (2018) on machine learning where are mentioned specific issues that affect logarithmic design such as the incorporation of both unintentional and intentional biases and lack of transparency of reached results by AI systems.

One example of bias was a risk assessment program named COMPAS[27], that was used by judges in the USA to estimate the likelihood of offenders to re-offend (probability of recidivism); the judges used the risk scores in their sentencing decisions. The program was found to be biased against black people, who received heavier sentences.

A second example included three facial analysis software from Microsoft, IBM and Face++, which had increasing fail rates in identifying the gender of people in photographs as their skin

[25] Tractica (21/12/2017), Artificial Intelligence Software Market to Reach $89.8 Billion in Annual Worldwide Revenue by 2025. https://www.tractica.com/newsroom/press-releases/artificial-intelligence-software-market-to-reach-89-8-billion-in-annual-worldwide-revenue-by-2025/ accessed 1/6/2018

[26] World Economic Forum Global Future Council on Human Rights 2016-18, (2018) White Paper How to Prevent discrimatory outcomes in Machine Learning. World Economic Forum

[27] Julia Angwin, Jeff Larson, Surya Mattu and Lauren Kirchner, ProPublica (23/5/2016), Machine Bias. https://www.propublica.org/article/machine-bias-risk-assessments-in-criminal-sentencing accessed 1/6/2018 and Matthias Spielkamp (12/6/2017), Inspecting algorithms for Bias. https://www.technologyreview.com/s/607955/inspecting-algorithms-for-bias/ accessed 1/6/2018

color[28] became darker; the error rate for light skin men was 0,8% and reached almost 35% for women with darker skin.

Both previous examples show that there are biases incorporated in the algorithms, which have already hindered or could hinder in the future the lives of people. AI augments biases.

Currently, researchers[29] are often unable to explain how the algorithms reach their answers/results. In addition, the US EOP (2016) report on preparing for the future of AI acknowledges the issue of opacity in AI systems' results. It highlights that the interpretability of the results produced by AI systems needs to be improved. Especially in AI applications that would assist doctors in diagnosis and other patient related decisions, is important to understand how the AI makes its decision. However, the complexity[30] of the algorithms makes very difficult to understand how the they reach their conclusions. In this context, the World Economic Forum (WEF)'s White paper emphasizes that when machine learning systems are engaged in decision making processes that affect the rights of the individual it should be properly communicated.

In this context, Ananny and Crawford (2018) discuss the application of AI algorithms in a variety of public systems in the USA such as healthcare and policing as facilitators of decision making. However, they argue that its will be difficult to make transparent the operation of algorithms especially for the purpose of allocating them accountability.

AI in weapons

The US EOP (2016) report Preparing for the future of AI[31] mentions the specific concerns that have been raised by various interested parties in the use of Lethal Autonomous Weapon Systems (LAWS), which would not require direct human control. Ethical, legal and plenty other issues need to be addressed before the use of weapons that autonomously select targets and engage with them.

[28] (2018). Gender and skin-type bias found in face analysis systems. Biometric technology today, 2018(3), Pages 2-3 and Steve Lohr (9/2/2018), Facial Recognition Is Accurate, if You're a White Guy https://www.nytimes.com/2018/02/09/technology/facial-recognition-race-artificial-intelligence.html accessed 1/6/2018 and Joy Buolamwini and Timnit Gebru (2018), "Gender shades: Intersectional Accuracy Disparities in Commercial Gender Classification", Proceedings of Machine Learning Research 81:1–15 . http://proceedings.mlr.press/v81/buolamwini18a/buolamwini18a.pdf

[29] Cliff Kuang (21/11/2017). Can A.I. Be Taught to Explain Itself? https://www.nytimes.com/2017/11/21/magazine/can-ai-be-taught-to-explain-itself.html accessed 1/6/2018

[30] Will Knight (11/4/2017), The Dark secret at the heart of AI. https://www.technologyreview.com/s/604087/the-dark-secret-at-the-heart-of-ai/ accessed 1/6/2018

[31] EOP (2016), "Preparing for the future of Artificial Intelligence". Pages 37-38

Superintelligence

Nick Bostrom[32](2014) defines superintelligence as 'any intellect that greatly exceeds the cognitive performance of humans in virtually all domains of interest" and warns about the risk that it could pose for society. Elon Musk and Stephen Hawkins have also warned[33] for the risks that AI could carry for mankind. The US EOP Intelligence report (2016) on Preparing for the future of AI also makes respective reference, although it dismisses the scenario that the machines might in the future become so powerful that would take the control from people and lead even to their extinction.

Concerns were raised about the possibility of AI to turn against the humanity and control their faith. Dubhashi and Lappin (2017), do not deny the scenario of superintelligence threatening the existence of people, but they conclude that the probability is small for the forthcoming future.

The main concern with superintelligent AI is that it will surpass the human in all aspects. In case that the scenario of superintelligent AI turning against AI is verified, there will be no turning back.

Conclusion

The AI technologies have already entered the daily routine of millions of people especially in the western world. The penetration of AI in the consumers market is high whereas in the corporate market is still small. AI is critical not only for the many opportunities for improvements in the economy and the life of people it brings but also for the dangers it conceals. In this section were mentioned some of the many advantages and disadvantages of AI. Keeping in mind the disruptive effect of AI will also help comprehend the relations between the three spheres of TH that are described below.

[32] Nick Bostrom (2014), Superintelligence: Paths, Dangers, and Strategies, Oxford University Press. page 26
[33] The economist (9/5/2015), The dawn of artificial intelligence
https://www.economist.com/leaders/2015/05/09/the-dawn-of-artificial-intelligence accessed 31/5/2018.

5. Triple Helix (TH) model

This section discusses the three spheres of the TH model, which are the government, the university and the industry. This chapter attempts to describe the system of Artificial Intelligence in the United States, which is the country leading currently the AI race, citing the history of AI research and analyzing the network of relations between the three spheres and how these have changed through the decades. The USA government has been financing the research in the field for many decades. Reference is lastly made to the social meta-innovation activities.

Description of the system

Schumpeter[34] (1943) argued for the importance of entrepreneurship in the growth of economy, highlighting the importance of entrepreneurs who "*reform or revolutionize the pattern of production by exploiting an invention or, more generally, an untried technological possibility for producing a new commodity or producing an old one in a new way, by opening up a new source of supply of materials or a new outlet for products by reorganising an industry and so on*". This is exactly the case with AI which applies new technological approaches and disrupts many industries at once. The AI ecosystem as will be described below is characterized by high levels of entrepreneurship both in the industry as well as in the academia, through start-ups springing from students or academic personnel.

Ranga and Etzkowitz[35] (2013) distinguish the following components of their TH system:

a) The components: which are the main spheres which incorporate a wide array of actors

b) The relationships between the components: from collaboration to conflict management, networking etc.

c) The functions, which correspond to the three spaces in the TH model, the "Knowledge space", the "Consensus space" and the "Innovation space".

Furthermore, Leydersdorff (2006) posits that the three institutions of the TH model construct a network with two layers. The first layer consists of relations in institutional level

[34] Joseph A. Schumpeter, Capitalism, Socialism and Democracy, Taylor & Francis e-Library, 2003, p.132. First print of the book was in 1943

[3535] Ranga, M. and H. Etzkowitz (2013), 'Triple Helix Systems: An Analytical Framework for Innovation Policy and Practice in the Knowledge Society", *Industry and Higher Education* 27 (4), Special Issue (August 2013), p. 8

by which they restrict each other's behavior; the second layer consists of their functional relations as they form and affect relative expectations. The institutional roles and environments alter through time.

The USA system briefly

The AI environment is shifting and complex. The AI system consists of mature stakeholders who engage in complex relations and interactions. The industry is highly concentrated and dominated by few conglomerates that expand through mergers and acquisitions and rule the data market (just to mention a few examples Google owns Android, Gmail, google maps, YouTube; Facebook owns Instagram and Whatsup; Microsoft owns SKYPE & LinkedIn).

The companies strive to set the standards in the market by providing open access to specific platforms (e.g. Google[36] offered free access to Tensorflow and Facebook to Caffe2). The governments (especially China and USA) are engaged in a race for the first one to reach general AI.

R&D innovators are present to all three spheres. The universities play an important role especially regarding the basic research in the field. Industry is the biggest investor in the USA in AI technology. The USA state is primarily funding the AI research in the public sector.

The legislation is trying to catch up with this speeding sector. The components of the system as well as the relations between them are of enormous importance to the society in general, as the stakes in AI technology are extremely high. The high dangers that accompany the new technologies have led many public figures to take a stand and warn the people.

While presenting the American TH model, partial information about China will also be provided since it is considered to be USA's major competitor in the AI field.

[36] The economist (7/12/2017), Google leads in the race to dominate artificial intelligence. https://www.economist.com/business/2017/12/07/google-leads-in-the-race-to-dominate-artificial-intelligence accessed 15/5/2018. Tensorflow and Caffe2 relate to machine learning software.

5.1 Government

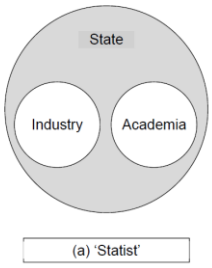
The US government has played an important role in the development of AI research. In order to understand the TH model in the US, there will be a short reference to history.

The federal government of the U.S. is focused mainly on the military applications of artificial intelligence. This becomes apparent from the fact that the Department of Defense (DoD) has the main supervision of the research in the AI field as well as in other technological sectors.

FitzGerald et al (2016) argue that Cold War influenced severely the military industry of the U.S. The country developed[37] in the Cold war era the so called "offset strategy", which was a defense strategy based on the premise that U.S. would achieve high technological superiority to win in the competition with Russia. The accomplishment of technological advantage is until today the characteristic/typical American defense approach. In this context the Department of Defence patronaged and sponsored the development of the relevant technologies. However, nowadays the development of the necessary technology stems from the industry and is out of the control of the DoD.

FitzGerald et al (2016) state[38] "*The United States cannot sustain technological superiority over its adversaries without a healthy and dynamic ecosystem of businesses supplying the Department of Defense*."

At the beginning of the AI research the TH model was statist. In this model, the state had the lead role, directing and supporting the university and the industry.



Graph 2. Source: Ranga and Etzkowitz (2013). Page 7.

[37]Ahton B. Carter and John P. White (2000), Keeping the Edge, Managing Defense in the future. PREVENTIVE DEFENSE PROJECT A research collaboration of the Kennedy School of Government Harvard University and Stanford University ASHTON B . CARTER AND WILLIAM J . PERRY, CO-DIRECTORS Cambridge, Massachusetts Stanford, California

[38] Ben FitzGerald, Alexandra Sander, and Jacqueline Parziale (2016), FUTURE FOUNDRY A New Strategic Approach to Military-Technical Advantage, Center for a New American Security, https://s3.amazonaws.com/files.cnas.org/documents/CNAS-Report-FutureFoundry-final.pdf?mtime=20161213162640. Page 37

5.1.1 The 1994 AI state

The U.S. government had identified[39] the importance of AI many years ago as a technology with great importance to the military as well as to the international competitive advantage of the state. Even since 1993, the US report identified that AI can be integrated with various software solutions and unfold as the "Knowledge Automation Industry". It was recognized its crucial role into turning information to knowledge. According to the report AI could be used both for civilian as well as military purposes.

The 1994 assessment report depicts in detail the structure of the AI industry at the period it was written and printed. The first component was research in the AI field, both basic and applied, which was performed by labs in the three main spheres of the model (G-U-I) as well as think tanks and various research companies.

The second component of the structure was the commercialization, which basically meant the application of technology into useful form and then offering it to the end users/customers for a price (or a cost if produced domestically). This consisted of consultants, internal industrial and governmental groups, vendors of AI technology and educational establishments such as universities.

The last component was the applications, which consisted of the private firms and the state agencies that acquire the AI technological applications as a key asset in order to improve their competitiveness and productivity. The challenge was in integrating information and knowledge and getting successful solutions to problems through automated systems.

The US Department of Defense (DoD) was in 1993, according to US 1994 assessment report, the biggest user of AI technology in the world, exceeding by far anyone else. It maintains that it headed globally the research in almost all AI fields due to the furtherance and support of the DoD.

Furthermore, the military was at that time the biggest financier of research and development in the AI areas of robotics and machine vision. Back then the most important hurdles in the

[39]ANON (1994), Critical technology assessment on the US artificial intelligence sector, Technical Report PB93-192409, US department of Commerce

country's leadership were first the slow pace of commercialization of AI and secondly the decreases in Defense funds dedicated to R&D.

The federal state funded 75% (circa 150million dollars per year) of the research in AI in the country during the period 1989-1994. 15-20% of the research was funded by the industry and the remaining percentage was sponsored by foreign sources.

According to the same report the US government funded about 75-80% of the research in universities. The industry, on the other hand, reported that a rate of almost 70-75% of their research was sponsored by the state. At that time, the main competitor of the USA was Japan, a county that was leading in fuzzy systems theory and was faster in the commercialization of applications.

The report[40] acknowledges that the foundations of the AI research are due to a few important AI universities as well as some companies, which explored and grew technology to the point that could be commercialized. These universities also fostered professors that acted as entrepreneurs and led to the creation of many start-up companies. These major pioneer universities were MIT, Stanford and Carnegie-Mellon (CMU). Pioneer companies included AT&T, the Palo Alto Research center of Xerox , Bolt, IBM etc.

The majority of the then top research institutions were heavily collaborating with the DoD.

Conclusively, the US government undertook several initiatives to promote its collaboration with the academia and the industry and sponsored heavily the R&D research in all levels.

5.1.2 The current state of AI

The US NSTC (2016) report accentuates the importance of AI in achieving and increasing the nation's economic prosperity.

The US NSTC[41] also discusses that AI is probably in the "third wave" phase which addresses the general AI technologies and the enhancement of current applications with explanatory &correction capabilities. The Federal state embraces the AI technologies in all forms and highlights its disruptive effect in all aspects of the economy. At the same time concerns are raised about a series of problems concerning the safety of AI technology for the people as well

[40]ANON (1994), Critical technology assessment on the US artificial intelligence sector, Technical Report PB93-192409, US department of Commerce

[41]NSTC, Networking and Information Technology Research and Development Subcommittee (2016), The national artificial intelligence research and development plan, Office of Science and Technology Policy. Page 14

as ethical and law implications which remain to be resolved; there is lack of adequate legislation generally in the advanced countries.

The US state proposed an "AI R&D" investments framework which depicts exactly the multifaceted effect of AI in the economy as well as the problems that came up. See graph 1.

The purpose of the graph is to highlight the level of analysis dedicated by the US state to the framework for AI and its implications for various sectors of the economy.

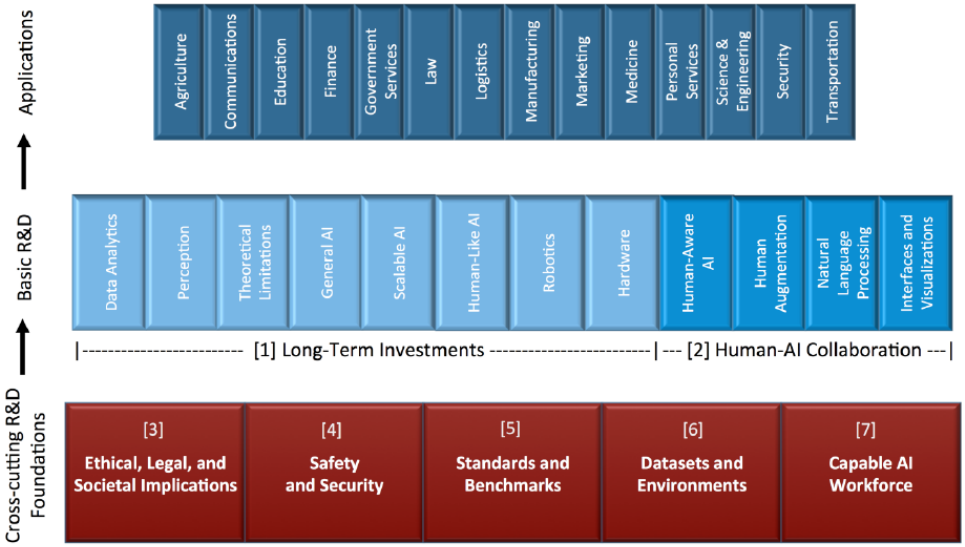


Figure 4. Organization of the AI R&D Strategic Plan. A combination of crosscutting R&D foundations (in the lower red row) are important for all AI research. Many basic AI R&D areas (in lighter and medium dark blue row) can build upon these crosscutting foundations to impact a wide array of societal applications (in top dark blue row). (The small numbers in brackets indicate the number of the Strategy in this plan that further develops each topic. The ordering of these Strategies does not indicate a priority of importance.)

Graph 3 Source: NSTC, Networking and Information Technology Research and Development Subcommittee (2016), The national artificial intelligence research and development plan, Office of Science and Technology Policy., p. 16

FitzGerald and Parziale (2017) discuss that national Defence departments, which used to sponsor and direct research in various technological fields have started to lose gradually their grip. The explanation lies to the fact that the developers of these new emerging technologies in the private sector have a huge international customer base which is bigger and more profitable compared to the limited purchasing power of military agencies. This is combined with the increased internal funding power of many private firms. The democratization of the use of new technologies leads to a decrease in the military control of countries. In the case of US, the state has through the years attempted to gain access to new technological solutions through collaborations with innovative start-ups and firms such as in Silicon Valley. According

to NY TIMES[42]the Pentagon has resorted to the companies in Silicon Valley to gain access to AI technology.

The limited influence of DoD over the industry is also discussed by FitzGerald et al (2016) where is described the conflict between the commercial interests of private firms and the incentives of the national defence market.

The dual application of recent AI technology, civilian and military has proved negative to the latter. The industry develops specialized technologies[43] which in order to be profitable require bulk orders. The small size of the DoD's orders and its limited resources are not financially attractive to the private sector any more. DoD is no longer the biggest buyer.

5.1.3 White House AI related publications

In 2015 and 2016 US agencies published documents concerning the effects of AI in the national economy. One of them was the "National Artificial Intelligence research and development strategic plan" which highlighted difficulties and challenges lying ahead and proposed a framework on how to respond. The framework consisted of the following seven strategies[44]:

"*1) Make long term investments in AI research*

2)Develop effective methods for human -AI collaboration

3)Understand and address the ethical, legal and societal implications of AI

4)Ensure the safety and security of AI systems

5) Develop shared pubic datasets and environments for AI training and testing

6) Measure and evaluate AI technologies through standards and benchmarks

7)Better understand the national AI R&D workforce needs"

The strategies proposed are long term and include a wide area of issues that need to be addressed. The importance of AI to the government becomes apparent from the fact that in 2016 it issued three[45] different reports on AI and the challenges AI would bring. In May 2018,

[42] Cade Metz (15/3/2018), Pentagon Wants Silicon Valley's Help on A.I., https://www.nytimes.com/2018/03/15/technology/military-artificial-intelligence.html accessed 20/5/2018

[43] Henny Sender (4/9/2016).US defense: Losing its edge in technology?. https://www.ft.com/content/a7203ec2-6ea4-11e6-9ac1-1055824ca907 accessed 16/4/2018

[44] NSTC, Networking and Information Technology Research and Development Subcommittee (2016), The national artificial intelligence research and development plan, Office of Science and Technology Policy, pages 3 and 4

[45] 1)EOP (2016), Artificial Intelligence, Automation, and the Economy 2)Executive Office of the President (EOP) (2016), "Preparing for the future of Artificial Intelligence and 3) NSTC, Networking and Information Technology

the White House organized a Summit[46] with representatives from the industry and the academia to discuss further the importance of it for the economy. The federal state has keen interest in all new developments and is kept abreast by the firms and the university.

5.1.4 Specific collaboration programs

The state has come up with various ways through which it collaborates with the other two helixes of the model. The collaboration patterns will be illustrated a bit further through the presentation of two governmental programs : DIUx and DARPA.

DIUx

One way of transferring knowledge from the Industry was with the creation of Defense Innovation Unit Experimental[47] (DIUx), through which commercial innovative applications would be used to achieve national defense targets. The DUIx organization was established in April 2015 to approach the Silicon Valley[48] industry. Offices were opened in various locations such as Texas, Austin and Silicon Valley. The DoD offered contract to companies in fields such as wireless communications, drones technology, cyber security, micro-satellites etc. During the last quarter of 2016, DIU provided 12 contract agreements with a cost up to 36 million dollars. This way the federal government attempted to approach non-traditional suppliers. In this context, in June 2017 Spark Cognition, an AI startup, announced collaboration with U.S. Air Force[49] that would focus on the analysis of the flow of information to improve the decision making[50] process.

Research and Development Subcommittee (2016), The national artificial intelligence research and development strategic plan, Office of Science and Technology Policy

[46] EOP(10/5/2018). Summary of the 2018 White House summit on artificial intelligence for American industry. The White House, Office of science and technology policy.

[47] Lisa Ferdinando (13/10/2016), DIUx Official: Working At 'Speed of Business' to Bring Tech to Warfighters. https://www.defense.gov/News/Article/Article/973315/diux-official-working-at-speed-of-business-to-bring-tech-to-warfighters/ accessed 15/4/2018 and http://www.defenseinnovationmarketplace.mil/DII_Defense_Innovation_Initiative.html accessed 15/4/2018

[48] Ben FitzGerald & Jacqueline Parziale (2017) As technology goes democratic, nations lose military control, Bulletin of the Atomic Scientists, 73:2, 102-107, DOI: 10.1080/00963402.2017.1288445

[49] Jennifer Kite-Powell (22/8/2017). United States Air Force Starts Artificial Intelligence Project To Analyze Flow Of Information. https://www.forbes.com/sites/jenniferhicks/2017/08/22/united-states-air-force-starts-artificial-intelligence-project-to-analyze-flow-of-information/#7f8903421534, accessed 16/4/2018

[50] Paige Williams (4/8/2017). DIUx awards AI contract to help Air Force decision-making. https://www.defensenews.com/home/2017/08/04/diux-awards-ai-contract-to-help-air-force-decision-making/ accessed 16/4/2018

DARPA Challenges

The US Defense Advanced Research Projects Agency (DARPA)has been organizing for years, starting in 2004, competitions (the so called "Grand challenges") in order to tap into the innovative pool of third parties. The first Grand Challenge related to autonomous ground vehicles. The premise[51] was to develop the necessary technology so as to substitute human drivers in dangerous military missions. The competition was repeated in 2005, when Stanford University's robot[52] Stanley won. That was the starting point for the promising self-driving vehicles technology which is heavily researched by major companies such as Tesla[53], Google, Uber, Apple[54] etc.

5.1.5 Concerns

Given the limited control of the government in the innovation of private companies, concerns are raised concerning their ability to regulate and moderate the potential risks from the new technologies.

One of the main missions of the government is to legislate and regulate the market. According to the "100 years study on AI" report the US government has appointed to different agencies the oversight of the various AI affected sectors e.g. the drones related is oversighted by the Federal Aviation Administration , whereas the AI used in financial markets is regulated by the Security Exchange Commission.

As new applications of AI are developed every day, new legislation needs to be drafted or the current legislation needs to be adjusted. The "100 year study on AI" report highlights the AI 's disruptive potentials as regards legislation, however calls for laws that won't hinder

[51](3/13/2014) The DARPA Grand Challenge: Ten Years Later. https://www.darpa.mil/news-events/2014-03-13 accessed 16/4/2018

[52]Sebastian Thrun, Mike Montemerlo, Hendrik Dahlkamp, David Stavens, Andrei Aron, James Diebel, Philip Fong, John Gale, Morgan Halpenny, Gabriel Hoffmann, Kenny Lau, Celia Oakley, Mark Palatucci, , Vaughan Pratt, Pascal Stang, Sven Strohband, Cedric Dupont, Lars-Erik Jendrossek, Christian Koelen, Charles Markey, Carlo Rummel, Joe van Niekerk, Eric Jensen, Philippe Alessandrini, Gary Bradski, Bob Davies, Scott Ettinger, Adrian Kaehler, Ara Nefian Pamela Mahoney. (2007) Stanley: The Robot That Won the DARPA Grand Challenge. In: Buehler M., Iagnemma K., Singh S. (eds) The 2005 DARPA Grand Challenge. Springer Tracts in Advanced Robotics, vol 36. Springer, Berlin, Heidelberg

[53]Ben FitzGerald & Jacqueline Parziale (2017) As technology goes democratic, nations lose military control, Bulletin of the Atomic Scientists, 73:2, 102-107, DOI: 10.1080/00963402.2017.1288445

[54]Stephen Nellis (22/11/2017), Apple scientists disclose self-driving car research. https://www.reuters.com/article/us-apple-autos/apple-scientists-disclose-self-driving-car-research-idUSKBN1DM08H accessed 16/4/2018

innovation. The authors discuss among others the need for strict transparency requisites and internal/external accountability.

5.2 The University

Etzkowitz and Dzisah (2008) analyze the character of the entrepreneurial university as a central notion in the TH model. The University has maintained its two original missions that is the training/education and research and added a third one, entrepreneurship. The university becomes more directly involved in the economic and social growth of its region, while at the same time turns to external actors for the acquisition of various resources for its development. MIT is the most prominent example they used.

Leydersdorff and Etzkowitz (2002) emphasize the importance of the entrepreneurial university, which they distinguish from the commercial university. They consider significant the way that each university will manage its different roles/goals towards a) adherence to society's goals e.g. priority programs, b) preparing/training highly skillful personnel and doing research that will conduce to the economy and c) its engagement towards the different academic traditions and the various disciplines; the need to redefine its boundaries both reflexively and in regard to the various field of studies. Each university has a different history and strives for resources in separate/diverse environments.

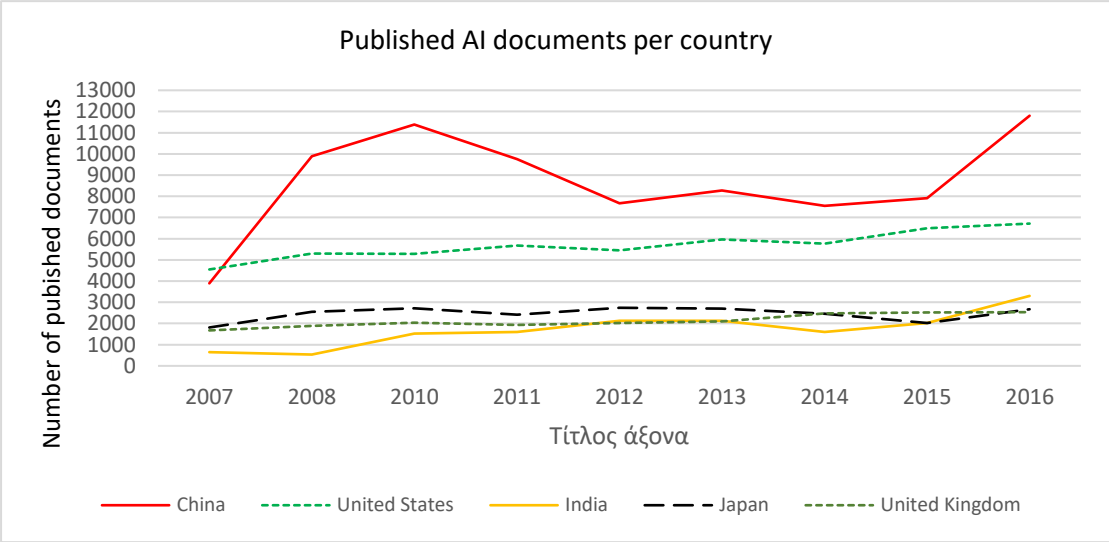
Etzkowitz (2007) explains the shift from bilateral relations between the three spheres into trilateral ones. The university does not only teach and produces knowledge but also becomes involved in technology transfer and the development of new products; the latter being traditionally the main function of the industry. He also mentions MIT university, a prestigious American university, as an example of entrepreneurial university that even from the decades of 1920 and 1930 developed formal ways of interacting with the industry such as the creation of a liaison office and the sale of IPR that the university could not exploit itself.

In USA flourish both private and public universities. According to the 1994 US report, as the AI field emerged and started to grow in the decade of the 1970s, AI research centers started to appear in increasingly many universities.

The site www.aiinternational.org has an extensive list with universities around the world that offer courses in Artificial Intelligence. In this list[55] are included 96 universities in the USA, the highest number than any other county.

5.2.1 Publication of research

The American universities perform AI research and they publish the results extensively. Academics value highly publications in terms of both quality and quantity. As far as publications related to AI are concerned, up to 2007 the USA were the major publisher of AI related papers. After 2007-2008 China entered the race and left the USA to the second place in terms of number of papers. The two graphs depict the clear difference between the USA, China and the rest of the countries.

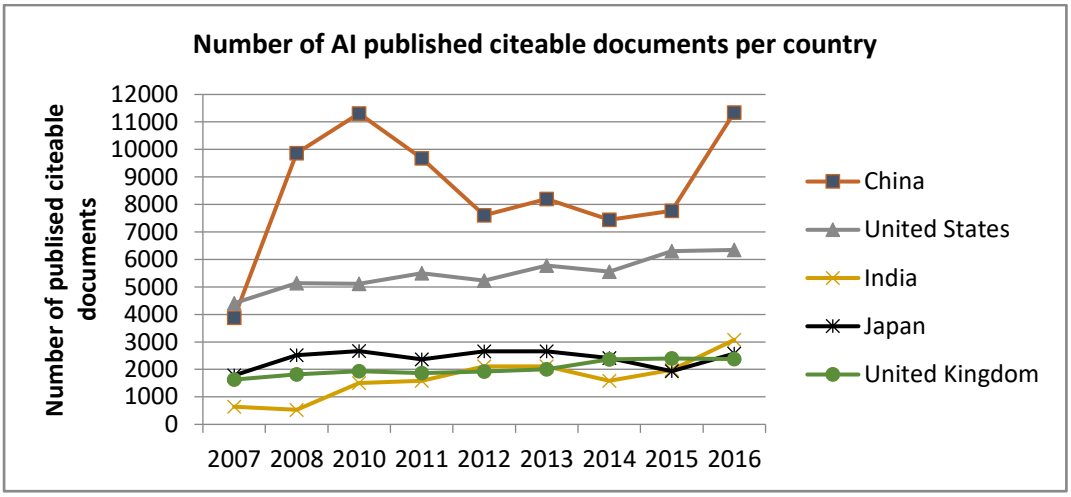


Graph 4

Source: http://www.scimagojr.com/countryrank.php accessed 9/3/2018 and formatted by the author of this paper

The above graph presents the number of published documents that relate to Artificial Intelligence. It is the "scientific output" of each country for each year. It is noticeable the change of countries in the top positions. China and USA have the two top positions, followed in the third place first from Japan, then the United Kingdom and thirdly India.

[55] http://www.aiinternational.org/universities.html accessed 12/4/2018



Graph 5

Source: http://www.scimagojr.com/countryrank.php accessed 9/3/2018 and formatted by the author of this paper

This graph depicts the number of published documents of each country relating to artificial intelligence that can be cited. These documents include reviews, papers as well as conference papers. As with the previous graph, China and USA reign the field. The difference with the other countries is considerable.

However, as far as the citation impact[56] weighted for the AI field is concerned, the USA lies in the fourth place (right behind Switzerland, Singapore and Hong Kong) whereas China is in the 34th place. China, the main competitor of USA, publishes many papers but with a lower impact rate. USA on the other hand has a lower impact rate.

A ranking listing of the world universities according to the impact of their citations, which is presented in the following table (for the same period). It shows which US universities are the most influential in publications.

[56] Simon Baker (22/5/2017). Which countries are leading on AI research?.https://www.timeshighereducation.com/data-bites/which-countries-and-universities-are-leading-ai-research accessed 20/5/2018

Institution	Country	Publications	Field-Weighted Citation Impact
Massachusetts Institute of Technology	United States	1.011	3.57
Carnegie Mellon University	United States	1.311	2.53
Nanyang Technological University	Singapore	1.197	2.51
University of Granada	Spain	587	2.46
University of Southern California	United States	627	2.35
Technical University of Munich	Germany	656	2.27
Institute of Automation, Chinese Academy of Sciences	China	588	2.26
Hong Kong Polytechnic University	Hong Kong	602	2.20
National University of Singapore	Singapore	807	2.14
Chinese University of Hong Kong	Hong Kong	530	2.09

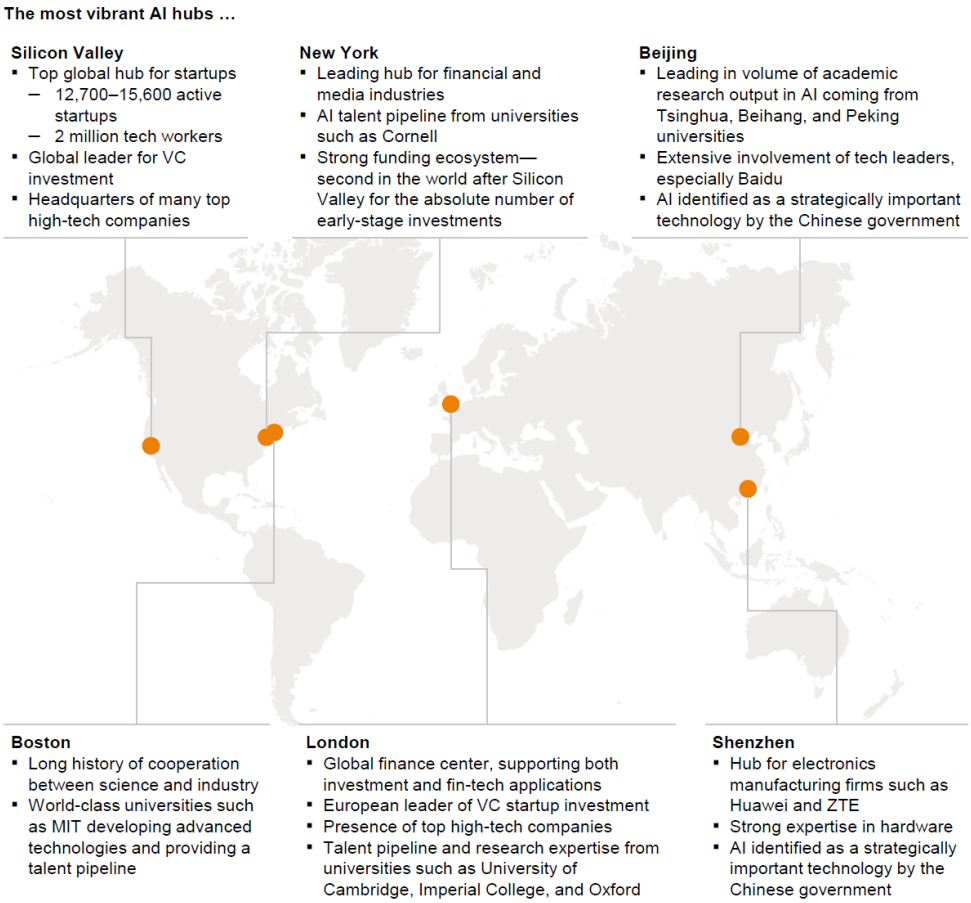
Table 1: Source:https://www.timeshighereducation.com/data-bites/which-countries-and-universities-are-leading-ai-research (Source: Elsevier/Scopus)

The table depicts the superiority of US universities in publishing their research. Universities such as MIT, Carnegie and USC are publishing high quality papers that have an impact on the field.

5.2.2 Universities at the heart of AI hub centers

According to MGI(2017) discussion paper the AI investment is concentrated in few geographical areas in the USA (received 66% of external[57] investment) and China (received 17% of external investment). Silicon Valley alone reached 40% in 2016. The report identifies three important US hubs: Silicon Valley, New York, Boston. The AI Hubs are crucial for the competitive advantage of the regions that they are located and subsequently of the nation. At the center of these hubs are well established universities.

[57] McKinsey Global Institute (MGI), Artificial Intelligence the Next digital frontier?, Discussion Paper June 2017, p. 39, where it is mentioned that external investment includes "*VC, PE and M&A activity*"



Graph 6: Source: McKinsey Global Institute (MGI), Artificial Intelligence the Next digital frontier? Discussion Paper June 2017, p.40.

The interactions of the university with the other two helixes, the government and the industry are complex and tight. In order to illustrate better the nature of the interactions, the graph 6 will be used as a guide to choose two universities. There will be a description of two major US universities that are famous for their AI research and are in the center of the Silicon Valley and Boston AI hubs; their interaction with the state and the private firms and how they interact with the state and the private firms.

Stanford

Many articles have been dedicated to the effect of universities in the entrepreneurship levels of their region. Silicon Valley is one of the most famous regions and is the international

hub of high tech companies. The story of the area is quite known. Frederik Terman[58], an electrical engineering professor who undertook director's postings in Stanford University and envisioned and worked to keep the graduates of his university in the area. He collaborated and supported startups and entrepreneurs in the area (Hewlett and Packard, later Intel) and created ties of the university to the industry. He is considered to be the "father of Silicon Valley", where today big AI companies such as Google, Apple, Facebook etc. are based.

SAIL[59], which stands for Stanford Artificial Intelligence Laboratory, has been performing top level research in various AI fields ever since 1962. The university has established affiliate[60] programs with select private firms (e.g. Tencent, DiDi and Panasonic); the latter pay 200.000usd per year during 3-yearprograms and can choose the field of AI that they wish to support and so gain early and better access to the subsequent research and researchers.

Furthermore, Stanford cooperates with Toyota through the SAIL-TOYOTA[61] Center for AI research center in the field of intelligent vehicles. The center is funded corporately. Researchers from both the university and the industry collaborate to promote research.

Stanford University's interaction with industry is so close that his previous president John Hennessy[62] also served on the boards of various firms.

Byers et al in their article conclude that the entrepreneurship of technical graduates and faculty of Stanford University is extremely important for the economic development of Silicon Valley.

Stanford supports local entrepreneurship through the StartX[63], which is a nonprofit accelerator program that started fostering the creation of startups from Stanford affiliated persons such as students, alumni, faculty staff member etc. Entrepreneurs with no affiliation can also benefit under specific conditions. There is also the Stanford-StartX fund that provides optional financing to the hosted startups. The program offers mentorship and networking.

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[58]Dawn Levy (3/11/2014), Biography revisits Fred Terman's roles in engineering, Stanford, Silicon Valley . https://news.stanford.edu/news/2004/november3/Terman-1103.html accessed 19/4/2018, The Guardian (4/10/2016). Frederick Terman: the Silicon Valley pioneer who shared his success https://www.theguardian.com/personal-investments/ng-interactive/2016/oct/04/frederick-terman-silicon-valley-mentor-stanford-hp accessed 19/4/2018.

[59] http://ai.stanford.edu/ accessed 19/4/2018

[60] Stanford Artificial Intelligence (13/2/2018), Overview for corporate members. http://ai.stanford.edu/wp-content/uploads/2018/02/Stanford-AI-Lab_corporate_overview_FEB132018.pdf

[61] https://aicenter.stanford.edu/about/ accessed 19/4/2018

[62] Bloomberg. Executive Profile of John L. Hennessy https://www.bloomberg.com/research/stocks/private/person.asp?personId=611152&privcapId=20497 accessed 5/6/2018

[63]https://en.wikipedia.org/wiki/StartX accessed 21/4/2018 and Ryan Lawer (8/3/2017). StartX, the accelerator for Stanford-affiliated entrepreneurs, gets a new CEO. https://techcrunch.com/2017/03/08/startx-new-ceo/ accessed 21/4/2018

StartX has partnered[64] with some major corporations such as Microsoft, Hyundai, amazon webservices, Facebook, NVidia etc.

The University also has some internationally known professors, such as Professor Andrew NG and Fei-Fei Li.

Massachusetts Institute of Technology (MIT)

MIT is a leading university in AI research and has contributed greatly in the development of its regional economy. Etzkowitz (2015) has repeatedly referred to MIT as the example of entrepreneurial university. He emphasized[65] the important role that the regional authorities played in cooperating and supporting the university in the latter's vision about enhancing the local economic activity by attracting branches of existing firms in the area, increasing the local technological level of SME and sponsoring and funding new science startups.

The MIT Computer science and artificial Intelligence Laboratory (CSAIL) is one of the biggest labs with a 65million[66] dollars research budget. Its predecessor was built in 1963 and was sponsored by the Department of Defense in order to create a computer system that would be available to groups. Hundreds of companies[67] were the result of spin offs that started in CSAIL including Boston Dynamics and Dropbox.

The connections between MIT and the industry are tight. MIT and IBM[68] will enter in 2018 in a 10 year collaboration for the creation of an MIT-IBM Watson lab. IBM will invest 240million USD in this project which will contribute to various AI fields such as AI hardware, algorithms etc. Joint research between personnel of MIT and IBM is expected to take place.

Both universities have been financed heavily by the government and work closely with the industry performing joint research. The ties are tight.

[64] https://startx.com/partners accessed 21/4/2018
[65] Henry Etzkowitz (2015), "Rendezvous of the "Third Kind": Triple Helix origins and future possibilities", INDUSTRY & HIGHER EDUCATION Vol 29, No 4, August 2015, pp 243–247, doi: 10.5367/ihe.2015.0267
[66] https://www.csail.mit.edu/about/mission-history accessed 22/4/2018
[67] https://www.csail.mit.edu/about/spin-offs accessed 22/4/2018
[68]Ron Miller (7/9/2017). IBM and MIT pen 10-year, $240M AI research partnership. https://techcrunch.com/2017/09/06/ibm-and-mit-pen-10-year-240m-ai-research-partnership/ accessed 1/6/2018

5.2.3 Patents ownership

According to the Bayh-Dole Act of 1980 the ownership of patents[69] that were developed using federal funding, would benefit the universities. This led to a sharp increase in the number of patents owned by universities, which have also profited from licensing revenues.

The law has been the result of a change in the US policymakers' mentality. Due to fiscal constraints, part of the federal funding that were directed to the research in universities had to be curtailed. The policymakers guided the universities to adapt their research so as to be closer to the needs of the industry. One such incentive (Cohen et al 2002) included the Bay Dole Act that facilitated the commercialization of the research performed in universities. The patents have allowed universities to make a profit out of their research and increase their income.

Conclusion

Etzkowitz (2015) posits that the successful American universities relied on a national financing policy that supported the creation of technology platforms in fields associated with defense and health. The government selects and sponsors specific sectors of technology and has used tools like the DARPA program to choose and fund technological candidates.

The collaboration of big tech companies with the academia is very common. Amazon collaborates with universities to promote AI skills in students. Specifically, Amazon has set up the Alexa Fund Fellowship, which will provide[70] cash funding to four universities (Carnegie Mellon University, Johns Hopkins University, University of Southern California and University of Waterloo) as well as infrastructure and corporate mentorship in order to create curriculum in voice technology. In addition, Facebook[71] has initiated the "Sponsored Academic Research Agreement" with 17 universities since 2016. The purpose is for universities to undertake specific research projects for Facebook by setting standard cooperation terms and eliminating bureaucratic issues. The universities include Harvard, Stanford, MIT, Caltech, Georgia Tech etc.

[69] Jason F Perkins and William G. Tierney (2014), The Bayh-Dole Act, technology transfer and the public interest, INDUSTRY & HIGHER EDUCATION Vol 28, No 2, April 2014, pp 143–151, doi: 10.5367/ihe.2014.0198

[70] https://developer.amazon.com/alexa-fund/alexa-fellowship accessed 25/4/2018

[71] Josh Constine (21/12/2016). Facebook's secretive hardware team signs rapid collaboration deal with 17 universities. https://techcrunch.com/2016/12/21/facebook-sara/ accessed 25/4/2018 and Caroline Perry (21/12/2016). A platform for rapid innovation. https://news.harvard.edu/gazette/story/2016/12/platform-for-rapid-innovation/ accessed 25/4/2018

In conclusion, the description of the government in combination with the description of the university show how closely these two helixes are interconnected. The state financed for years the academic AI research and inventions like the internet[72] were the outcome. The universities are at the center of not just American but also international AI hubs. From the examples presented becomes apparent the strong collaboration between the university and the industry as well. Big corporate firms choose to perform co-research with the academia. The university is identified as a critical innovation actor in the system by the other two helixes.

5.3 Industry

The industry is one of the most important pillars in the AI TH model and as mentioned above has undertaken the lead role in the AI research. Corea[73] (2017) highlights that almost 60% of the AI companies are based in the USA.

It is highly concentrated with a few companies leading the AI race. Investing in AI technology is an expensive hobby. Most of the investment in the industry stems from internal funding[74] of large corporations.

The leading AI companies internationally, as depicted in Statista (2017) report along with their respective expertise area, are all but one American. The list is in the following graph, where its shows that Amazon, Apple, Google, Facebook, Microsoft and IBM are the biggest firms in the sector.

[72] Barry M. Leiner, Vinton G. Cerf, David D. Clark, Robert E. Kahn, Leonard Kleinrock, Daniel C. Lynch, Jon Postel, Larry G. Roberts, Stephen Wolff (1997). Introduction. https://www.internetsociety.org/internet/history-internet/brief-history-internet/ accessed 24/5/2018

[73] Francesco Corea (2017), "Artificial Intelligence & exponential technologies: Business Models evolution and New Investment Opportunities". Springer, chapter 4, page 31

[74] McKinsey Global Institute (MGI), Artificial Intelligence the Next digital frontier?. Discussion Paper June 2017

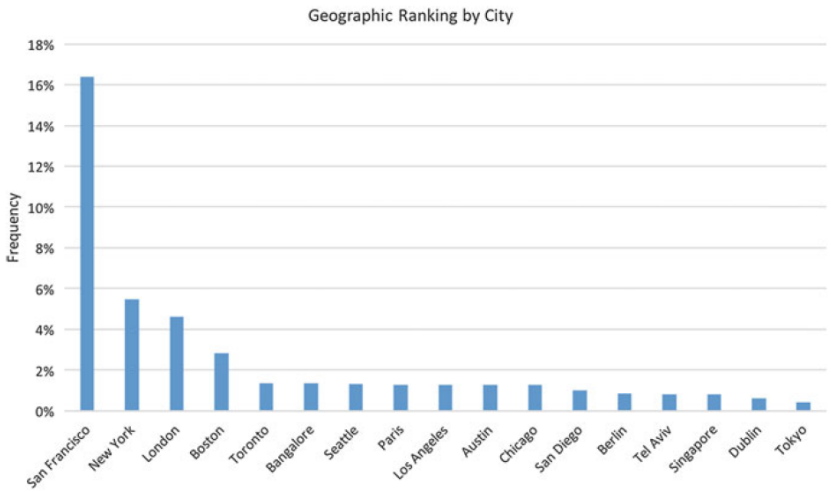
Comparison of leading AI companies

Company	*Headquarter*	*Revenue in bnUS$[1]*	*Market cap. in bnUS$[1]*	*Key AI Areas*
Amazon	Washington	136.0	356.3	Text-to-speech, computer vision, deep learning, NLP
Apple	California	229.2[2]	609.0	Machine learning
Baidu	Beijing	10.2	57.0	Machine learning, robotics
eBay	California	9.0	33.2	Predictive analytics, cloud based AI, and big data
Facebook	California	27.6	31.6	Language technology, machine learning, computer vision
Google	California	90.3	539.1	Machine learning, deep learning, automotive
IBM	New York	80.0	157.8	Machine learning, cognitive architectures
Microsoft	Washington	90.0[3]	483.2	Machine vision, machine learning, healthcare
Salesforce	California	8.4[4]	47.7	Machine learning, analytics
Uber	California	20.0	68.0[5]	Voice and image recognition, machine learning, automotive

1: As of Dec 2016 2: As of Sep 2017 3: As of June 2017 4: As of Jan 2017 5: Valuation As of April 2017
Source: Annual Reports, Corporate News Letters

Table 2: Source: Statista Report 2017, Artificial Intelligence p.79

Apart from the big corporations, the AI field is full of new startups. Corea (2017) emphasizes the importance of a triple combination: talent, infrastructure and capital for the prosperity of an ecosystem. He identified the top 15 cities in the world with the highest concentration of AI related startups. The fact that half of the cities are in the USA is indicative of country's importance in the AI field.



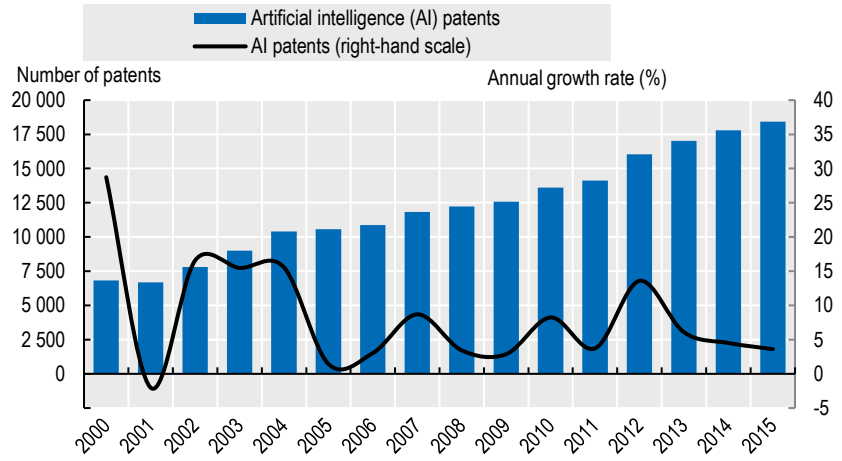
Graph no 7: Source: Francesco Corea (2017), "Artificial Intelligence & exponential technologies: Business Models evolution and New Investment Opportunities". Springer, chapter 4, page 32.

Extensive external funding, including Venture Capital firms is available for their financing. The year 2017 was the first one that China[75] outweighed the USA (38%) in the global equity investment in AI start-ups (48%) even though it represents a mere 9% of international AI related deals. In 2017 China's share was 11,3 % .

According to MGI' s report[76] the big tech companies are expanding extensively acquiring a quite large number of start-ups the main purpose to gain access to highly qualified personnel. This method, however deprives the economy from scientists that would do alternative research compared to the commercially oriented research that is usually performed by big tech companies in niches aligned with their corporate product priorities.

5.3.1 Patents

An important indicator to measure the advancement in a sector is the number of inventions patented throughout the years. The number of patents related to AI technologies increased 6% every year during the period 2010-2015[77], which is twice the average yearly patent growth rate in all domains. Bear in mind that AI, as will be presented shortly, is one of the sectors that is being heavily invested in. The field is constantly expanding and all firms strive to be the pioneer. The data used are from OECD[78] and stem from the top 5 IP offices (IP5).



***Graph no 8: Source*: OECD, STI Micro-data Lab: Intellectual Property Database, *http://oe.cd/ipstats* June 2017**

[75] CBInsights (2018). State of artificial intelligence 2018, p.6
[76] McKinsey Global Institute, "Artificial Intelligence: The next digital frontier?", page 11
[77] OECD SCIENCE, TECHNOLOGY AND INDUSTRY SCOREBOARD 2017: THE DIGITAL TRANSFORMATION. OECD 2017. Page 22
[78] OECD SCIENCE, TECHNOLOGY AND INDUSTRY SCOREBOARD 2017: THE DIGITAL TRANSFORMATION. OECD Publishing Paris. Page 22

The graph represents the rapid increase in the number of the patents throughout the years.

As far as the distribution of patents per country and company is concerned, Fujii and Managi (2018) performed an analysis, according to which the US companies IBM, Microsoft and Qualcomm lead the race. The authors emphasize also the importance of US universities as inventors of AI technology. The following table summarizes the patent analysis calculated by the authors.

The graph shows that the companies are very protective of their intellectual property. As discussed previously, the US universities can benefit financially from their patents. However, one closer look shows reveals that the number of patents granted and technology portfolios of US universities the period 2000- 2016 is considerably smaller than the number owned by the big American companies. The big difference in the number of patents verifies that the largest part of applied AI research takes place in the industry.

Table 3
Number of AI patents granted and technology portfolios: 2000 to 2016.
Source: Author estimate using IPC codes in Appendix 1 and PATSTAT database.

Rank	Applicant name	Country	Total patents	Patent portfolio of AI technology			
				Biological	Knowledge	Mathematical	Other
1	IBM	USA	1057	22%	56%	8%	14%
2	Microsoft	USA	466	22%	44%	9%	24%
3	Qualcomm	USA	450	83%	7%	3%	7%
4	NEC	Japan	255	23%	49%	8%	20%
5	Sony	Japan	212	51%	33%	6%	10%
6	Google	USA	195	41%	36%	7%	17%
7	Siemens	Germany	192	54%	31%	10%	5%
8	Fujitsu	Japan	154	27%	60%	9%	4%
9	Samsung	Korea	119	56%	28%	3%	13%
10	NTT	Japan	94	35%	49%	0%	16%
11	Hewlett-Packard	USA	93	22%	44%	4%	30%
12	Yahoo	USA	88	14%	57%	16%	14%
13	Toshiba	Japan	86	22%	57%	7%	14%
14	D-wave	Canada	77	1%	4%	3%	92%
15	Hitachi	Japan	69	20%	38%	12%	30%
15	SAP	USA	69	23%	70%	6%	1%
17	Canon	Japan	68	59%	28%	3%	10%
18	Xerox	USA	62	15%	45%	18%	23%
19	GE	USA	59	14%	59%	22%	5%
20	Mitsubishi Electric	Japan	53	49%	43%	2%	6%
21	Honeywell	USA	49	24%	51%	22%	2%
22	Boeing	USA	48	31%	60%	4%	4%
23	Cisco	USA	47	15%	38%	0%	47%
23	Oracle	USA	47	17%	55%	9%	19%
25	British Telecomm	UK	44	41%	57%	2%	0%
26	Intel	USA	43	35%	51%	5%	9%
27	Amazon	USA	41	15%	39%	2%	44%
28	Brain Corporation	USA	40	80%	15%	3%	3%
28	Cognitive scale	USA	40	0%	88%	0%	13%
28	Facebook	USA	40	0%	40%	13%	48%
	University total	World	1177	69%	19%	6%	6%
	U.S. university	USA	241	41%	38%	7%	14%
	Chinese university	China	725	82%	10%	5%	3%
	Japanese university	Japan	93	83%	15%	1%	1%

Table 3: Source: Fujii, H., & Managi, S. (2018). Trends and priority shifts in artificial intelligence technology invention: A global patent analysis. Economic analysis and policy, 58, 60-69. doi: 10.1016/j.eap.2017.12.006, page 65.

One company of the few that prevail in the industry was selected to illustrate the extensive and elaborate relationships between the three helixes of the model. The selection was due to the company's extensive product/services portfolio.

5.3.2 Google

Google was founded by two students[79] at Stanford university in 1998. Larry Page and Sergei Brin met in 1995 as PhD students[80] and created a search engine to evaluate the importance of webpages in internet. algorithm for searches of information. That was the start of the company Google Inc with the mission to "*organize*[81] *the world's information and make it universally accessible and useful*". The company went public in 2004. In October 2015 the company[82] Alphabet Inc. was created as the parent company to Google. The company owns several international and popular brands such as: Android operating system for mobile phones, Chrome explorer, Google maps, Gmail, AdSense and AdWords marketing services, Utube video platform, etc. Google is an international conglomerate.

Google's flagship is its search engine, which is the undisputable leader in the global market of internet search engines. Its share in the search engines market[83] reaches up to 75% in a global level and around 63% in the US the last three years.

The main source of revenue for the company comes from advertising. Based on the data[84] in the company's annual report, for the years 2015-2017, the international advertising revenues comprise on average 88% of the total revenues. Almost 47% of the company's international revenues stems from the United States.

[79] Todd A. Finkle (2011), "Corporate Entrepreneurship and innovation in Silicon Valley: The case of Google, Inc.", Baylor University

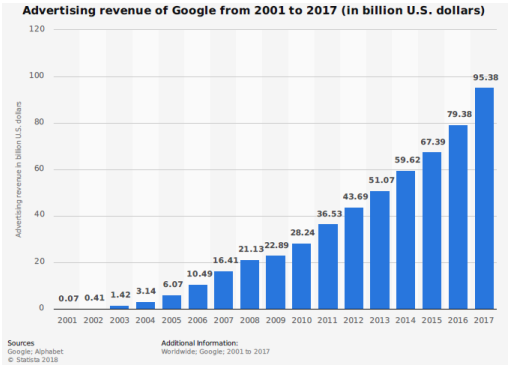
[80] https://www.google.com/intl/en/about/our-story/ accessed 23/4/2018

[81] Alphabet Inc. Form 10-K, For the Fiscal Year Ended December 31, 2017 (https://abc.xyz/investor/pdf/20171231_alphabet_10K.pdf). page 4

[82] Cusumano, Michael (2016), "Is Google's alphabet a good bet?", Communications of the ACM, 20 December 2016, Vol.60(1), pp.22-25

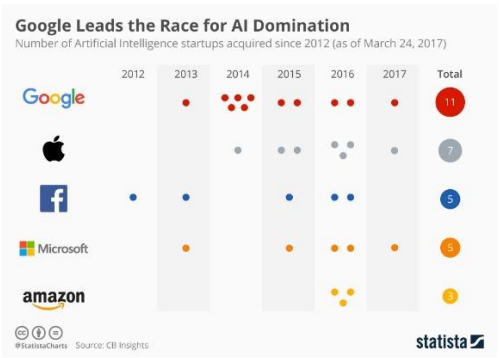
[83] Statista (2018)."Market share of search engines in the United States from December 2008 to 2017" and Statista (2017). "Worldwide desktop market share of leading search engines from January 2010 to October 2017".

[84] Alphabet Inc. Form 10-K, For the Fiscal Year Ended December 31, 2017, https://abc.xyz/investor/pdf/20171231_alphabet_10K.pdf, page 58



Graph 9. Source: Alphabet. n.d. Google's ad revenue from 2001 to 2017 (in billion U.S. dollars). Statista. Accessed 23 April, 2018. Available from https://www-statista-com.zorac.aub.aau.dk/statistics/266249/advertising-revenue-of-google/.

Google incorporates strategic AI technologies and researchers by mergers and acquisitions. The company made headlines in 2014 when it paid an estimated price of 400 million English pounds to acquire the London based[85] company DeepMind. Deepmind 's main asset was its group of machine learning and not only experts, led by Demis Hassabis. Google's search engine and the advertising services are counting on machine learning. After the acquisition, in 2016, an AI program[86] was developed that won the South Korean Champion of the game Go, which is considered to be extremely complex.



Graph 10: Source: https://www-statista-com.zorac.aub.aau.dk/chart/9443/ai-acquisitions/

The graph depicts Google's dominance in acquiring the greater number of AI startups (11) compared to other[87] competitors It is indicative of the expansive tendencies of the big players in the sector.

[85] The economist (1/2/2014). Don't be evil, genius. https://www.economist.com/news/business/21595462-google-buys-british-artificial-intelligence-startup-dont-be-evil-genius and The economist (15/12/2016). What DeepMind brings to Alphabet. https://www.economist.com/news/business/21711946-ai-firms-main-value-alphabet-new-kind-algorithm-factory-what-deepmind-brings accessed 24/4/2018

[86]The economist (15/12/2016). What DeepMind brings to Alphabet. https://www.economist.com/news/business/21711946-ai-firms-main-value-alphabet-new-kind-algorithm-factory-what-deepmind-brings accessed 24/4/2018

[87] Check the appendix A for the complete list of companies acquired as prepared by CB insights.

Google along with Facebook have an added share of circa 80% of referral traffic[88], which means referring web users to news publishers and subsequently news articles.

Competition cases

In 2017 Google received a huge fine of 2,4 billion[89] euros for the anticompetitive behavior of promoting its own comparison-shopping services in Google shopping by taking advantage of her dominance as a search platform. EU is also examining a probable case of Google forcing the manufactures of phones that use the android operating system to include other Google apps as well.

The same antitrust cases have been examined by the US FTC (Fair Trade Commission that handles competition law issues) in 2013 in the USA but the case[90] was dismissed claiming that Google admittedly hurt competitors but did it to offer better services to its customer. Google undertook some commitments and was cleared. Kovacic[91] (2018) also comments on the US weakness in intervening against the national dominant firms such as Google and offers various explanations. Hazan (2013) emphasizes the monopolistic power of Google and the occasional abuse of it and brings specific examples of Google undermining the visibility of its direct competitors such as Yelp! and other search verticals websites.

Google and the government

Google's relation with the government has been through various tides. One of the reasons has been the fact that the Federal Government has repeatedly asked Google[92] to provide access to the data its users. In addition, when Google bought the companies Shaft and Boston

[88] Jeff Dunn (25/5/2017). Facebook and Google dominate web traffic, but not the same kind. http://nordic.businessinsider.com/google-facebook-news-traffic-chart-2017-5?r=US&IR=T accessed 24/4/2018 and The economist (20/1/2018). The techlash against Amazon, Facebook and Google—and what they can do. https://www.economist.com/news/briefing/21735026-which-antitrust-remedies-welcome-which-fight-techlash-against-amazon-facebook-and accessed 24/4/2018

[89] Daniel Boffey (11/9/2017). Google appeals against EU's €2.4bn fine over search engine results. https://www.theguardian.com/technology/2017/sep/11/google-appeals-eu-fine-search-engine-results-shopping-service accessed 25/4/2018

[90]Greg Ip (16/1/2018). The Antitrust Case Against Facebook, Google and Amazon. https://www.wsj.com/articles/the-antitrust-case-against-facebook-google-amazon-and-apple-1516121561 accessed 24/4/2018

[91] William E. Kovacic, Two Views of Exclusion: Why the European Union and the United States Diverged on Google, 9th April 2018, https://promarket.org/two-views-exclusion-european-union-united-states-diverged-google/ accessed on 24/4/2018

[92] Source: Statista dossier about Google (2018), page 74

Dynamics, which were among the winners of another DARPA competition and stopped their cooperation with DoD.

Google is currently working with the US department of defense to utilize Tensorflow technology by analyzing videos produced by drones. The so-called project Maven aims at improving the object recognition in videos; Maven[93] is part of a 4.7 billion dollars budget dedicated by DoD to AI and data processing. The possible military implications [94] have led to thousands of Google employees campaigning for the end of this project and signing an open letter against it.

The DoD launched in 2016 the Defense Innovation Board[95] (DIB) which will be advising the Secretary of Defence on various technological, structural and other challenges that the DoD faces. Members of the DIB are people from both the academia and the industry such as Eric Schmidt (Alphabet Inc), Marve Levine (COO Instagram), Milo Medin (VP Google Capital), Neil Degrasse Tyson (Hayden Planetarium) etc.

Google and universities

Google has initiated the Google in Residence (GIR) programs[96] which are intense training programs for researchers in the AI field. In the context of GIR Google has a long-term cooperation with Howard University[97] which will be enhanced through a three-month summer CS residency program. The GIR program has led to the incorporation of Google engineers as faculty in the university.

In conclusion, Google is a leading AI company with multiple areas of interest/research and strong collaboration both with the government as well as the universities. It is one of the most aggressive companies in terms of expansion and acquisition of valuable resources.

[93] Samuel Gibbs (7/3/2018). Google's AI is being used by US military drone programme. https://www.theguardian.com/technology/2018/mar/07/google-ai-us-department-of-defense-military-drone-project-maven-tensorflow accessed 25/4/2018

[94] Scott Shane and Daisuke Wakabayashi (4/4/2018). 'The Business of War': Google Employees Protest Work for the Pentagon. https://www.nytimes.com/2018/04/04/technology/google-letter-ceo-pentagon-project.html accessed 25/4/2018.

[95] http://innovation.defense.gov/ accessed 25/4/2018

[96] https://research.google.com/teams/brain/residency/ accessed 25/4/2018

[97] Brittany Bell Surratt (23/3/2017). Howard University Partners with Google to Launch 'Howard West'. https://newsroom.howard.edu/newsroom/static/7116/howard-university-partners-google-launch-howard-west accessed 25/4/2018

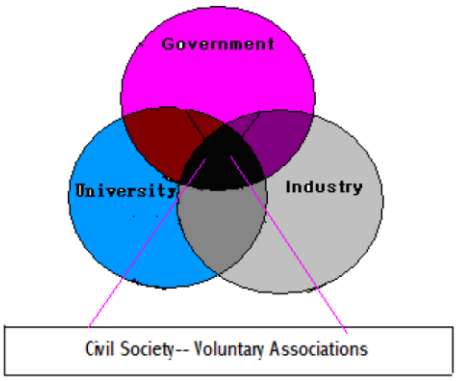
5.3.3. Law and regulations

According to the "100 year study on AI" report[98]: "*As regards AI, critical infrastructure is notably defined by the end-user application, and not the technology or sector that actually produces AI software. Software companies such as Google, Facebook, and Amazon have actively lobbied to avoid being designated as critical to the economy, arguing that this would open the door to regulation that would inevitably compromise their rapid product development cycles and ability to innovate. Nonetheless, as the companies creating, operating, and maintaining critical infrastructure use AI, interest will grow in regulating that software*."

Given that the Industry is now the leading of the three helixes in the AI research, the reluctance of the firms to be regulated is worrying.

5.4 Social meta-innovation

Etzkowitz (2007) discusses the evolution to a meta-innovation system, as the interactions and the initiatives between the TH actors increase. This dynamic presupposes the existence of an active civil society, in which the different units are encouraged to undertake initiatives, organize freely and debate.



Graph 11: Source: Etzkowitz (2007), p. 15, Figure 1-4 : Social structure of Triple Helix.

[98] Peter Stone, Rodney Brooks, Erik Brynjolfsson, Ryan Calo, Oren Etzioni, Greg Hager, Julia Hirschberg, Shivaram Kalyanakrishnan, Ece Kamar, Sarit Kraus, Kevin Leyton-Brown, David Parkes, William Press, AnnaLee Saxenian, Julie Shah, Milind Tambe, and Astro Teller. "Artificial Intelligence and Life in 2030." One Hundred Year Study on Artificial Intelligence: Report of the 2015-2016 Study Panel, Stanford University, Stanford, CA, September 2016. Doc: http://ai100.stanford.edu/2016-report, P. 44-45

This "social structure" is especially strong and present in the AI field, given the dangers that could arise from the possible mismanagement of Artificial intelligence applications and the uncertainty concerning its future. Examples of this social structure in the AI field could be considered the following three:

The partnership: The biggest companies in the AI field have joined forces by establishing the "Partnership[99] on AI to benefit people and society". The headquarters of the organization are in San Fransisco, in California. The founding companies are Amazon, Apple, Deepmind, Google, Facebook, IBM and Microsoft. As presented in their website, the companies identify the crucial point into which AI research is currently; thus, they created this partnership with the purpose to develop and establish good practices in the AI field, inform and educate the public about AI and its applications, share insights, promote research etc. This partnership was later joined by other companies such as McKinsey[100] as well as Academics[101] and NGOs.

Open letter: In January 2015 Stephen Hawking and Elon Musk along with many other AI experts signed an open letter[102] with the title "Research priorities[103] for Robust and Beneficial artificial intelligence" regarding AI and how its fast development calls for research to ensure that AI systems will be controlled by man and will be useful and favorable to the society. Ever since a number of similar letters have been signed including one for banning the creation and use of autonomous weapons. The letter was supported by the Future of Life organization, which is based in Boston and aims at "*keeping artificial[104] intelligence beneficial and we are also exploring ways of reducing risks from nuclear weapons and biotechnology*".

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[99] https://www.partnershiponai.org/ accessed 20/4/2018

[100] McKinsey & Company (30/6/2017). McKinsey joins the Partnership on AI to Benefit People and Society. https://www.mckinsey.com/about-us/new-at-mckinsey-blog/mckinsey-joins-the-partnership-on-ai-to-benefit-people-and-society

[101]https://www.partnershiponai.org/partners/ accessed 12/4/2018. In the webpage of the organization the list of partners include the following The Association for the Advancement of Artificial Intelligence (AAAI), the American Civil Liberties Union (ACLU), Affectiva, AI FORUM NEW ZEALAND, AI NOW INSTITUTE (a research center that is based on the New York University), THE ALLEN INSTITUTE FOR ARTIFICIAL INTELLIGENCE (AI2), AMNESTY INTERNATIONAL, ASSOCIATION FOR COMPUTING MACHINERY (ACM),The Center for Information Technology Policy in Princeton University, CENTRE FOR INTERNET AND SOCIETY, INDIA (CIS), DIGITAL ASIA HUB (research think tank with its base in Hong Kong), EBAY, INTEL , ACCENTURE , OpenAI etc. It is apparent that there are international inputs in this organization.

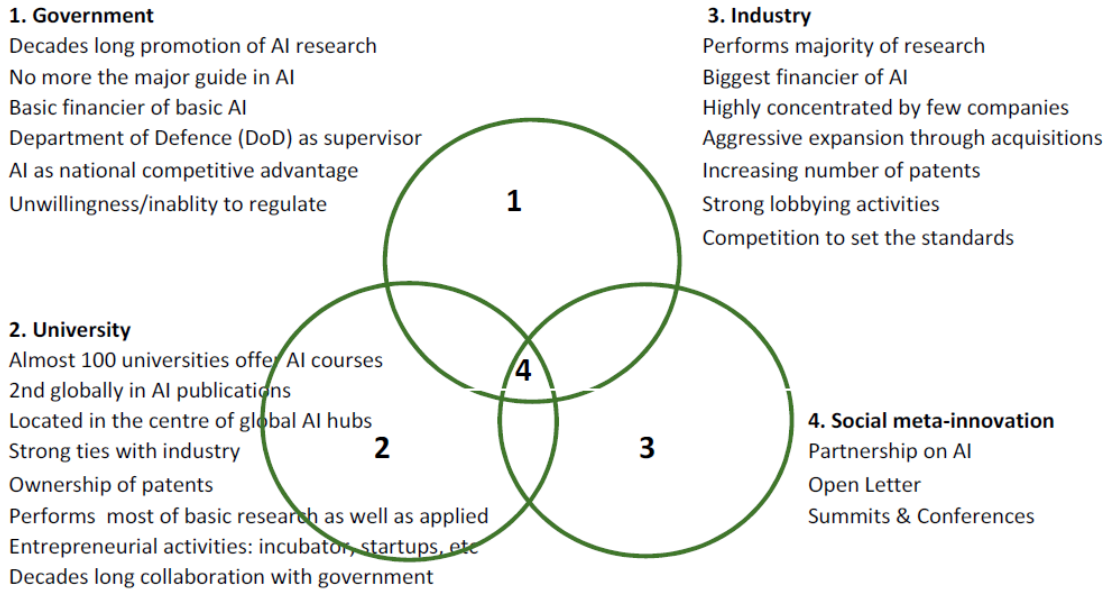
[102] https://en.wikipedia.org/wiki/Open_Letter_on_Artificial_Intelligence accessed 22/4/2018, Guia Marie Del Prado (27/7/2015). Stephen Hawking, Elon Musk, Steve Wozniak and over 1,000 AI researchers co-signed an open letter to ban killer robots .http://www.businessinsider.com/stephen-hawking-elon-musk-sign-open-letter-to-ban-killer-robots-2015-7?r=US&IR=T&IR=T accessed 22/4/2018, https://futureoflife.org/ai-open-letter accessed 22/4/2018

[103] Stuart Russell, Daniel Dewey, Max Tegmark (2015). Research Priorities for Robust and Beneficial Artificial Intelligence. Association for the advancement of artificial intelligence https://futureoflife.org/data/documents/research_priorities.pdf?x17807 accessed 22/4/2018

[104] https://futureoflife.org/data/documents/research_priorities.pdf?x17807 accessed 22/4/2018

AI Conferences and Summits: The number of AI conferences organized is growing every year. Government employees from various agencies, the industry and the academia have the opportunity to meet multiple times per year and discuss developments in the field through many conferences and summits. One of the most important AI conferences takes place each year in Canada[105] and is called "Conference on Neural Information Processing Systems".

5.5 Summary of the TH model



Graph 12: the AI TH system in the USA. Prepared by the author

The graph summarizes the main characteristics of the AI TH system in the USA

The AI Triple Helix model in the USA has a long history of at least 50 years. At the beginning the government would sponsor both the universities and the industry to engage in AI related research. The government still has strategic alliances both with the corporations as well as with the universities especially in military application of new technologies. It relies on the two other helixes to be kept up-to-date with new developments. The state finances mostly basic research. AI is considered to offer competitive advantage in the country and thus the state is reluctant to intervene regulatory. To this contribute the lobbying activities of the industry as

[105] The economist (2/4/2016). Million-dollar babies. https://www.economist.com/news/business/21695908-silicon-valley-fights-talent-universities-struggle-hold-their accessed 19/4/2018

well. It should be noted though, that the complexity of the new AI technologies have raised multiple difficult legal issues which no country has managed to address so far.

The industry is leading the race to AI, by investing heavily in the development and commercial exploitation of AI. There are few big tech companies with a vast array of products/services and expand by acquiring start-ups and companies with useful resources. The university has undertaken an entrepreneurial role and certain universities are in the center of international AI hubs. Both the government and the industry acknowledge the significance of university and its research assets and enter in partnerships and collaboration projects with academics.

The TH model portrays the dynamics in the AI field. The system evolved through the years and now the industry from a simple participant in the AI research has turned to the leader of research. However, in order to understand the shift taking place the last years, one should also examine the BIG DATA. AI applications require abundance of data. Thus, the BIG DATA will be presented in the next chapter.

6. BIG DATA

In this section there will be a brief reference to the BIG DATA, because they are required for the training of AI. Their quality and quantity affect immensely the development of AI. The misuse of BIG DATA via advanced AI algorithms has caused turbulence in the actors of the AI system. For all these reasons their analysis is crucial in understanding in depth the AI TH model in the USA.

This chapter will clarify what the term BIG DATA entails and how these are usually collected. In addition, examples will be provided of their misuse and of the implications that these had. At end will be provided insights in the regulatory framework of AI

BIG DATA and AI

BIG DATA Analytics as is the complete title are used to train the AI algorithms. They have been used, among other things, to provide AI applications with information concerning people and the society.

The US NSTC in its 2016 report on the national AI R& strategic plan argues that the latest wave of growth in AI was supported by the availability of BIG DATA, which were collected from various sources such as social media, the government etc, the improvement in machine learning and the algorithms and the advancement of computer power.

The US NSTC report underlines the importance of the provision of good quality data for the training of AI. It emphasizes the need for the development of new and better tools in order to understand intelligent data and uncover data's hidden knowledge. To this point, the "Federal[106] Big Data Research and Development Strategic Plan" was developed.

Evry Norge AS 's white paper[107] also emphasises the fact that it is not accidental the latest enormous interest in AI to happen at the same time with the establishment of BIG DATA. It highlights that the greatest investors in AI are the companies that have access to vast amounts of data such as google, Facebook, Microsoft and Baidu. In addition, Evry names two more

[106]The networking and information technology research and development program (2016). The Federal Big Data Research and Development Strategic Plan. NITRD.

[107] Evry. The New Wave of Artificial Intelligence https://www.evry.com/globalassets/insight/bank2020/the-new-wave-of-artificial-intelligence---labs-whitepaper.pdf

factors that have affected greatly the development of AI: the shrinking cost of computer power and the development of Artificial[108] Neural Networks (ANN).

MGI in the 2017 discussion paper discusses[109] the importance of data for the AI growth. Companies need to evaluate the data they have and figure out how to gain access to the data that they need. This includes gaining access to data that with relational structure. The report predicts that the competition for data that relate to real time people's geolocational details will become fiercer.

In conclusion BIG DATA is a valuable industry by itself and the companies that have access to them benefit in multiple ways. The establishment and expansion of technologies that facilitated the collection of all kinds of data, has contributed immensely to the development of AI.

6.1 The term BIG DATA

The use of the term Big Data has been credited[110] to John Mashey in the mid-90s, who was working at that time in the Silicon Graphics company as Chief scientist. According to Gupta and George (2016), there is no clear definition of what Big Data are.

IBM defines BIG DATA as follows[111]:

"*Big data analytics is the use of advanced analytic techniques against very large, diverse data sets that include structured, semi-structured and unstructured data, from different sources, and in different sizes from terabytes to zettabytes. Big data is a term applied to data sets whose size or type is beyond the ability of traditional relational databases to capture, manage, and process the data with low-latency. And it has one or more of the following characteristics – high volume, high velocity, or high variety. Big data comes from sensors, devices, video/audio, networks, log files, transactional applications, web, and social media - much of it generated in real time and in a very large scale*."

Wamba et al (2015) compiled an interesting table with various descriptions of BIG DATA content through the respective literature.

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[108] Evry. The New Wave of Artificial Intelligence https://www.evry.com/globalassets/insight/bank2020/the-new-wave-of-artificial-intelligence---labs-whitepaper.pdf, pages 6-9

[109] McKinsey Global Institute (MGI), Artificial Intelligence the Next digital frontier? Discussion Paper June 2017

[110] Diebold F (2012) A personal perspective on the origin(s) and development of 'big data': The phenomenon, the term, and the discipline. http://www.ssc.upenn.edu/fdiebold/papers/paper112/Diebold_Big_Data.pdf accessed 29/4/2018

[111] https://www.ibm.com/analytics/hadoop/big-data-analytics accessed 30/4/2018

(IBM, 2012b)	Big Data: data captured from sensors, posts to social media sites, digital pictures and videos, purchase transaction records, and cell phone GPS signals, etc.
(Johnson, 2012)	Big Data: extremely large sets of data related to consumer behavior, social network posts, geotagging, sensor outputs (p. 21).
(Davenport et al., 2012)	Big Data: data from everything including click stream data from the Web to genomic and proteomic data from biological research and medicine
(Manyika et al., 2011)	Big Data: datasets with a size that is beyond the ability of typical database software tools to capture, store, manage, and analyze
(Rouse, 2011)	Big Data: description of the voluminous amount of unstructured and semi-structured data a company creates or data that would take too much time and cost too much money to load into a relational database for analysis
(Fisher et al., 2012)	Big Data: data that cannot be handled and processed in a straightforward manner (p. 53)
(Havens et al., 2012)	Big Data: data that you cannot load into your computer's working memory (p. 1130)
(Jacobs, 2009)	Big Data: data that is too large to be placed in a relational database and analyzed with the help of a desktop statistics/visualization package—data, perhaps, whose analysis requires massively parallel software running on tens, hundreds, or even thousands of servers. (p. 44)
(IDC, 2013)	Big Data has three main characteristics of Big Data: the data itself, the analytics of the data, and the presentation of the results of the analytics. Then there are the products and services that can be wrapped around one or all of these Big Data elements (p. 1)
(Boyd and Crawford, 2012)	Big Data: a cultural, technological, and scholarly phenomenon that rests on the interplay of (1) Technology: maximizing computation power and algorithmic accuracy to gather, analyze, link, and compare large data sets. (2) Analysis: drawing on large data sets to identify patterns in order to make economic, social, technical, and legal claims. (3) Mythology: the widespread belief that large data sets offer a higher form of intelligence and knowledge that can generate insights that were previously impossible, with the aura of truth, objectivity, and accuracy. (p. 663).

Table no 4.
Source: Fosso Wamba, S, Akter, S, Edwards, A. (2015) How 'Big data' can make big impact: Findings from a systematic review and a longitudinal case study. International Journal of Production Economics 165(July): 234–246, page 236, part of table 1

The quality of the data that are used to train AI will also shape AI's perception of the world and the society.

Kitchin and McArdle (2016) tried to work on the characteristics that categorise various sets of data as Big data. They built on Doug Laney's previous work about the 3 basic characteristics of data volume[112], velocity and variety (known as 3Vs) and further worked using 26 known datasets characterised as Big Data in literature to see whether there are specific traits that are common in all of them. They concluded that not even the 3Vs apply at all times and further work needs to be performed to specify what falls into the term Big Data. They identified a list of datasets that cover almost all aspects of human activity[113].

Jin et al (2015) added to the features of BIG DATA besides the 3VS also veracity (which addresses the trustworthiness of data) and high Value.

Marcus Krajewski[114] (2017) addresses BIG data as "*a promise to tackle (and master) one of the three basic functions of media (storage, transmission and processing)*". He argues that the first two, namely the storage and the transmission are achieved through the advanced technology. On the other hand, processing appears to be more difficult. He argues that even though agencies gather all kinds of data, the analysis and processing of all this data to find the information/knowledge is very difficult. The author concludes that metadata are equally

[112] Doug Laney (2001), "3D data Management: Controlling Data Volume, Velocity and Variety", MetaGroup Inc https://blogs.gartner.com/doug-laney/files/2012/01/ad949-3D-Data-Management-Controlling-Data-Volume-Velocity-and-Variety.pdf accessed 29/4/2018 and M. C. Elish & danah boyd (2018) Situating methods in the magic of Big Data and AI, Communication Monographs, 85:1, 57-80, DOI: 10.1080/03637751.2017.137513

[113] See the Appendix B for a copy of their table with the BIG DATA

[114] Krajewski, M. (2017). Tell Data from Meta: Tracing the Origins of Big Data, Bibliometrics, and the OPAC. Osiris, 32(1), 224-240. doi: 10.1086/694228. Page 237

important with data and revealing. "*The metadata*[115] *of Internet providers (i.e., who called whom and the duration of the call) are just as instructive as the contents of the respective phone calls, maybe even more conclusive. The subterfuge often used by notorious data collectors (NSA, F8, Apple, and various telecommunication companies), claiming not to be interested in the contents, which are supposedly left untouched, is once again proven wrong. The difference between "meta" and "data" always collapses easily and repeatedly, just as the distinction between signal and noise depends on the parameters of the search.* "

Han et al[116] (2012) discuss the privacy threat that poses the use of mobiles phone. Mobile phones are being tracked by various applications just by installing them. Furthermore, trackers are used that are constant in time such as the IMEI number of the device or the mobile phone number. Mobile phones provide a variety of data (both sensor and personal data such as photos, contacts, calls and email histories etc.) which are collected and often transmitted without encryption to third parties through applications. Real time tracking of users takes places massively and includes person specific identifying information.

Pybus et al (2015) also discuss the huge leak of personal data that takes place each time one uses platforms such as Facebook, Google or Messenger in his smartphone. They argue, among others, for the importance of data literacy and people understanding what data they generate and how they are being disseminated.

G. Bello-Orgaz[117] et al (2016) comment on the importance of social networks in the creation of BIG DATA as manifested through social media such as Facebook. He calls them "social big data" and highlights their impact in the analysis of human behavior related to crime prediction, health epidemics and marketing efficiency improvement.

According to the economist[118], the use of internet and smartphones have led to an abundance of data, which are more valuable today. The connection of various devices with internet contributes plainly to the increase in the volume of data, the value of which has only recently began to be estimated. The big technology firms profit from the network effects.

[115] Krajewski, M. (2017). Tell Data from Meta: Tracing the Origins of Big Data, Bibliometrics, and the OPAC. Osiris, 32(1), 224-240. doi: 10.1086/694228, page 238

[116] Han S, Jung J and Wetherall D (2012), A study of third-party tracking by mobile apps in the wild. Report, University of Washington, US. Available at: ftp://ftp.cs.washington.edu/tr/2012/03/UW-CSE-12-03-01.PDF

[117] Bello Orgaz, G., & Bello-Orgaz. (2016). Social big data: Recent achievements and new challenges. Information fusion, 28, 45-.

[118] The economist (6/5/2017), Data is giving rise to a new economy. https://www.economist.com/briefing/2017/05/06/data-is-giving-rise-to-a-new-economy accessed 5/5/2018

Anderson[119] (2008) discusses the effect of Big Data on scientific methods, arguing that the analytics and statistics performed on Big data are adequate to reveal the mechanisms that connect two variables. Finding the patterns is the important thing. He proposes that correlation is more significant than causation and science can advance without unified models or theories.

In a similar context, Peter Bearman (2015) argues over the significant help that the analysis of Big Data has offered in distinguishing patterns while working with historical archives of various sources such as the seating chart of NY Philharmonic Orchestra, data of prison incarceration etc. BIG DATA served into identifying various mechanisms in the social and political history of the USA.

Ben Williamson[120] (2014) in his article highlights the shift in the social science research from the university to big corporations such as Facebook and Google, which use algorithms and BIG DATA analysis and analysts to decipher and gain insight into human behaviour patterns. The huge generation of daily data about the lives of people through the social media platforms and the use of algorithms allow for new tools to reveal and visualise social patterns. Williamson calls for attention about the effects of the performance of previously academic work by the social media corporations. Reference is also made to the US government that has established policy labs (such as the New York Governance Lab that is based on the NY university), which adapt an experimenting, interdisciplinary and exploratory view on governance[121] innovations and their effect on people's lives.

Cathy o' Neil (2016) presented many examples where the use of inappropriate or biased set of data has led AI algorithms to wrong/biased decisions. She calls the AI algorithms Weapons of Math destruction given their effect on big populations and warns about the caution that is required when choosing databases to base decisions on as well as and the necessity to make transparent and explainable the decisions reached by algorithms.

[119] Anderson, Chris (23/6/2008), "The End of Theory: The Data Deluge Makes the Scientific Method Obsolete," Wired, www.wired.com/2008/06/ pb-theory/. Accessed 30/4/2018

[120] Williamson Benn (10/2/2014), The death of the theorist and the emergence of data and algorithms in digital social research. The Impact blog, The London School of Economics and Political Science, http://blogs.lse.ac.uk/impactofsocialsciences/2014/02/10/the-death-of-the-theorist-in-digital-social-research/ . accessed 30/4/2018

[121] http://thegovlab.org/about/ accessed 30/4/2018

The previous analysis revealed that BIG DATA contain all kinds of information – private, sensitive- and are being collected without people even noticing it. The advanced AI algorithms can take all these data and turn them into valuable information and unveil one' s way of thinking, habits and social life among other things. Unfortunately, this information could be used for legal and illegal purposes.

6.2 The Value of BIG DATA for the system

This section will comment on two cases where BIG DATA have caused international scandals. These cases are cited here to underline the significance and value of data as well as their vulnerability in the digital society. The first case revealed the importance of BIG DATA for the US government through the Snowden scandal.

a) Snowden

In June 2013 Edward Snowden, a former CIA employee and subsequently a contractor for the American government, revealed that the National Security Agency (NSA) in the US has been involved in the systematic surveillance of the telecommunications[122] as well as of the electronic communication of people, firms and foreign governments. The NSA is claimed to have obtained access to the data in the servers of the biggest USA companies[123] such as Apple, Google, Facebook, Microsoft, Skype and Yahoo among others. The documents provided by Snowden revealed[124] that the intelligence services in European countries such as the UK, France, Spain and Germany have been applying similar practices of surveillance and storage of data. According to Zygmunt Bauman et al (2014), the NSA, among other agencies, either collaborated with or forced private corporations such as Microsoft, Google, Apple as well as telecommunication providers to gain access to the data of their customers.

[122] Glenn Greenwald (6/6/2013). NSA collecting phone records of millions of Verizon customers daily.https://www.theguardian.com/world/2013/jun/06/nsa-phone-records-verizon-court-order accessed 5/5/2018

[123] Glenn Greenwald and Ewen MacAskill (7/6/2013), NSA Prism program taps in to user data of Apple, Google and others .https://www.theguardian.com/world/2013/jun/06/us-tech-giants-nsa-data. Accessed 5/5/2018

[124] Christian Fuchs, Daniel Trottier, (2017) "Internet surveillance after Snowden: A critical empirical study of computer experts' attitudes on commercial and state surveillance of the Internet and social media post-Edward Snowden", Journal of Information, Communication and Ethics in Society, Vol. 15 Issue: 4, pp.412-444, https://doi.org/10.1108/JICES-01-2016-0004

The actual meaning of BIG Data is what the NSA is currently performing. "*These various practices*[125] *for intercepting communication are both complex and interconnected and are designed to secretly process personal data. Such data consist of both content (recordings of phone calls, text messages, images of web-cams, substance of email messages, entries on Facebook, the history of an Internet user's access to Web sites, and so on), and metacontent (data recording the means of creation of transmitted data, the time and date of its creation, its creator, and the location where created). Once gathered, both data and metadata are retained for a certain period of time (as in Tempora) and then organized through platform s of integration (such as PRISM) to become intelligible by means of the visualization of networks, beginning with persons or Internet addresses that are already under suspicion*."

The impact was huge and caused considerable questions concerning the privacy of citizens. As the AI algorithms evolve over time and reveal unknown patterns, the collection and processing of all these data could provide unique power to the owner of the new information.

b) Cambridge Analytica

A second example that emphasizes most the impact of misuse of the strongly interrelated AI and BIG DATA, is the Cambridge Analytica scandal.

M.C Elish and Danah Boyd[126] (2018) describe the chain of events that led to the scandal concerning the last elections in the USA. Shortly after the election of D. Trump as the 45th president of the US, articles appeared concerning the involvement of the company Cambridge Analytica, a political consultancy firm which was hired for the elections' campaign, in processing the data provided by Facebook users to profile them and then target them with direct marketing tools and direct them towards actions that would support the campaign. Cambridge Analytica is said to have accessed and collected the Facebook profiles of over 50 million American users, through a third-party researcher[127] who gathered the data for

[125] Zygmunt Bauman, Didier Bigo, Paulo Esteves, Elspeth Guild, Vivienne Jabri, David Lyon and R. B. J. Walker (2014) "After Snowden: Rethinking the impact of Surveillance", International Political , Sociology, Volume 8, Issue 2, 1 June 2014, Pages 121–144, https://doi.org/10.1111/ips.12048, page 123

[126] M. C. Elish & Danah Boyd (2018) Situating methods in the magic of Big Data and AI, Communication Monographs, 85:1, 57-80, DOI: 10.1080/03637751.2017.137513 and McKenzie Funk (19/11/2016). Cambridge Analytica and the Secret Agenda of a Facebook Quiz. https://www.nytimes.com/2016/11/20/opinion/cambridge-analytica-facebook-quiz.html accessed 1/5/2018

[127] Matthew Rosenberg (22/4/2018). Professor Apologizes for Helping Cambridge Analytica Harvest Facebook Data https://www.nytimes.com/2018/04/22/business/media/cambridge-analytica-aleksandr-kogan.html and Julia Carrie Wong, Paul Lewis and Harry Davies (24/4/2018). How academic at centre of Facebook scandal tried – and failed – to spin personal data into gold. https://www.theguardian.com/news/2018/apr/24/aleksandr-kogan-cambridge-analytica-facebook-data-business-ventures both accessed 20/5/2018

academic purposes. The algorithms[128] used by Cambridge Analytica[129] along with other tools could lead to the development of psychographic and political profiles for thousands of people.

NY Times[130] have issued a series of articles highlighting the scandal. Facebook CEO Mark Zuckerberg was called to testify before the congress on the 10th of April due to the scandal. A campaign[131] was initiated that called for people to delete their Facebook account. The importance of the story was in the revelation that Facebook can't protect the data of its users. The hearing of the company's CEO showed that the representatives of the Congress[132], the policy makers, could not understand the business model of Facebook.

This raises questions how the US policymakers will manage to regulate the new technology-based markets if they can't understand it. Technology is evolving daily and the governments need to keep up. However, the most important issue is that when data are being processed by capable people with the use of algorithms, especially AI algorithms, extremely valuable information about the profiles of people can be produced. This sensitive information provides the power for a possible mass manipulation of people or other legal or illegal uses.

6.3 Data legislation

US privacy protection legislation

The BIG DATA have raised considerable concerns concerning the protection of the privacy of citizens. According to Eric Horvitz[133] and Deirdre Mulligan (2016), the US Administration

[128] Carole Cadwalladr, Emma Graham-Harrison (17/3/2018). How Cambridge Analytica turned Facebook 'likes' into a lucrative political tool. https://www.theguardian.com/technology/2018/mar/17/facebook-cambridge-analytica-kogan-data-algorithm accessed 20/5/2018

[129] Natasha Lomas (29/3/2018). Here's Cambridge Analytica's plan for voters' Facebook data https://techcrunch.com/2018/03/29/heres-cambridge-analyticas-plan-for-voters-facebook-data/?guccounter=1 accessed 30/5/2018

[130] Nicholas Confessore (4/4/2018). Cambridge Analytica and Facebook: The Scandal and the Fallout So Far. https://www.nytimes.com/2018/04/04/us/politics/cambridge-analytica-scandal-fallout.html accessed 1/5/2018

[131] The economist (9/4/2018). Why is Mark Zuckerberg testifying in Congress?. https://www.economist.com/blogs/economist-explains/2018/04/economist-explains-7 accessed 1/5/2018

[132] Margaret Sullivan (10/4/2018).Members of Congress can't possibly regulate Facebook. They don't understand it. https://www.washingtonpost.com/lifestyle/style/members-of-congress-cant-possibly-regulate-facebook-they-dont-understand-it/2018/04/10/27fa163e-3cd1-11e8-8d53-eba0ed2371cc_story.html?noredirect=on&utm_term=.57371b3cba92 accessed 1/5/2018 and The economist (14/4/2018). What to make of Mark Zuckerberg's testimony. https://www.economist.com/news/leaders/21740401-both-facebook-boss-and-his-questioners-congress-fail-reassure-what-make-mark accessed 1/5/2018

[133] Eric Horvitz and Deirdre Mulligan (2016), "Data, Privacy and the greater good", Artificial Intelligence, 17 July 2015, vol 349 (6245), pages 253-255

government highlights distinctly the proposal of regulations that apply to the use of data and not their collection. According to the Economist[134], the USA lack regulatory framework to protect the privacy of its citizens, with certain exceptions when it comes to health-related data.

According to Bonnie Kaplan (2015), in the US the protection of privacy is limited and there is a lack of a covering all privacy protection framework. Similarly, Brad Turner (2015)[135] refers to the US law provision that people should have no expectation of protecting their privacy concerning the information that they knowingly expose to others. He also describes the ways that the US government gathers citizens' data both directly (first hand through police surveillance) and indirectly (through third parties: a) simply asking or legally requiring data from companies such as Facebook, Google, Verizon etc and b) intercepting into telecommunication cables internally and internationally).

The US have a patchwork[136] of laws that address privacy issues by sector and not as a framework. Different agencies and regulations apply to the supervision and protection of data in different sectors of the economy. There are considerable gaps when it comes to protecting the online privacy and the data of people.

Big Data bring in the forefront the privacy issues. According to Corea[137] (2017), new measures need to be undertaken to address the new challenges and differential privacy is one of them.

GDPR

The European Union has adopted a stricter policy towards the protection of personal data and the privacy of Europeans. On the 25th of May 2018 took effect the EU's General Data Protection Regulation (GDPR). The law applies to the data of European citizens that were collected while they were in the EU, but were transferred to companies outside the EU, which have no physical presence in the EU.

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[134] The economist (5/4/2018). America should borrow from Europe's data-privacy law. https://www.economist.com/news/leaders/21739961-gdprs-premise-consumers-should-be-charge-their-own-personal-data-right accessed 1/5/2018

[135] Brad Turner (2015) "When big data meets big brother: Why courts should apply United States v. Jones to protect people's data", 16 North Carolina Journal of Law and Technology 377 (2015), page 3 and 14

[136] Natasha Singer (30/3/2013). An American Quilt of Privacy Laws, Incomplete https://www.nytimes.com/2013/03/31/technology/in-privacy-laws-an-incomplete-american-quilt.html accessed 1/5/2018 and Nuala 'o Connor (30/1/2018). Reforming the U.S. Approach to Data Protection and Privacy https://www.cfr.org/report/reforming-us-approach-data-protection accessed 1/5/2018

[137] Francesco Corea (2017), "Artificial Intelligence & exponential technologies: Business Models evolution and New Investment Opportunities". Springer, chapter 4.

The definition[138] of the terms privacy and sensitive data is completely different in the US and in the EU under the GDPR.

The GDPR requires amongst others that the individuals provide explicit consent about the use of their personal data[139]. Moreover, the individual has a right to receive his collected data in a structured[140], widely used and machine-readable format (portable data).

The GDPR is already affecting the US based tech companies such as Facebook[141] and Google, which have started updating their privacy policies.

Conclusion

The BIG DATA analysis verified the power of the industry in getting access to and making profit out of often personal and sensitive data of the consumers. The companies act in a loosely regulated sector and without taking usually into consideration the protection of their users and the benefit of the society. The two cases described above, Snowden and Cambridge Analytica, are examples of misuse of data by two of the helixes of the system, the government and the industry. When data are combined with algorithms valuable knowledge is produced that can be used for beneficial or manipulative purposes. There are questions regarding how these two helixes could promote the regulation and ethical deployment of AI technologies, given their sometimes arbitrary attitude towards the use of sensitive and personal data.

The BIG DATA section offered a better perspective of their value, their significance in the training and use of AI technologies and their contribution towards the enhancement of the role of big companies in the AI race.

[138] Hodge, N. (2018). GETTING READY FOR GDPR. Risk Management, 65(1), 26-29.
[139] Marc Cornock, General Data Protection Regulation (GDPR) and implications for research, Maturitas, Volume 111, 2018, Pages A1-A2, ISSN 0378-5122
[140] https://gdpr-info.eu/art-20-gdpr/ accessed 1/5/2018
[141]https://www.facebook.com/business/gdpr and
https://privacy.google.com/businesses/compliance/#?modal_active=none accessed 1/5/2018

7. The privatization of research in the AI system

The previous chapters portrayed the changes in the dynamics of the AI system in the USA and especially the prominent role that the industry has gained in the AI research field. This chapter borrows the term “privatization of research” used by Archibugi and Filippetti (2018) to describe aspects of the industry’s new enhanced role and will study its effect on the system. The consequences of the intense recruitment of academics by the industry as well as the differences between the research produced by the industry and the academia will be discussed.

Privatization of research

Archibugi and Filippetti (2018) address the issue of the privatization of research and knowledge, which they posit has been underestimated or severely ignored. They argue that during the last decades the public investment in R&D has decreased while at the same time has flourished private investment in R&D, which has led to the private sector producing a bigger proportion of knowledge. The authors present the differences in the characteristics of the knowledge produced in the public versus the private sector and support that the decrease in publicly funded research and knowledge creation takes its toll on innovation and has negative impact on the long-term growth of economy and society.

The TH model has provided the framework within which will be analysed the phenomenon discussed during the previous chapters concerning the enhanced role of the industry in the AI system. The term privatization of the research in the AI field, has the following characteristics. The lead in the research of AI technologies is performed at a great extent by the industry, which has by far surpass the university in one of its basic roles. The private sector is the biggest financier of the AI research. In addition, the academia personnel are being decimated by big corporations. The main investor of AI research is officially the industry in the USA.

The various implications of the phenomenon on the university, the economy and the society will be presented straight away.

7.1 Brain flight to industry: Lack of professors to teach the students

One of the most discussed consequences of the privatization of the AI research has been the recruiting of academic personnel and especially prominent professors to the industry. Gibney[142] (2017) discusses the huge demand for expertise employees in the AI field by the industry. The huge and abrupt development of AI field the last years and especially of machine learning has created a huge demand for properly trained employees. According to Indeed.com, a website with job advertisements, there has been a 500% increase in the number of advertisements[143] related to jobs in the AI sector. A 61% of the increase was for ML engineers, 10% for data scientists and a humble 3% for general software development.

Currently there is not available an adequate number of skilled employees to respond to this huge demand. This has led the big private companies to search for employees within the academia.

The NY times [144] discusses the recruiting of high qualified AI professors by the industry and lists a number of universities where that took place including Stanford University, the university of Washington and Carnegie Mellon. In 2015, UBER[145] recruited 40 out of 140 personnel that were employed in Carnegie Mellon's robotics lab. In February of 2015, UBER and Carnegie Mellon[146] announced their cooperation and by May six principal investigators and 34 engineers (including Tony Stentz and program directors) fled the lab for UBER. According to the paper, Carnegie Mellon was one of only few institutions that offered a PhD in robotics.

In September[147] 2015, UBER offered the university a 5.5 million dollars donation , which was interpreted[148] as an attempt to make amends. However, it is questionable, whether this

[142] Elizabeth Gibney (2016), "AI firm lure academics", Nature, Vol 532, (28/4/2016), page 422-423

[143] James Ovenden (4/1/2018). How To Solve The AI Brain Drain. With the brightest minds fleeing academia for private enterprise, is there a way to stem the tide? https://channels.theinnovationenterprise.com/articles/how-to-solve-the-ai-brain-drain

[144] Cade Metz (22/10/2017). Tech Giants Are Paying Huge Salaries for Scarce A.I. Talent https://www.nytimes.com/2017/10/22/technology/artificial-intelligence-experts-salaries.html accessed 15/4/2018

[145] The economist (2/4/2016). Million-dollar babies. https://www.economist.com/business/2016/04/02/million-dollar-babies accessed 17/5/2018

[146] Ramsey, Mike; MacMillan, Douglas. "Carnegie Mellon Reels After Uber Lures Away Researchers; Uber staffs new tech center with researchers poached from its collaborator on self-driving technology". Wall Street Journal (Online); New York, N.Y. [New York, N.Y]31 May 2015, https://www.wsj.com/articles/is-uber-a-friend-or-foe-of-carnegie-mellon-in-robotics-1433084582 accessed 17/5/2018

[147] Ken Walters (9/9/2015). Carnegie Mellon Receives $5.5M Gift from Uber for Professorship and Graduate Fellowships. https://www.cmu.edu/news/stories/archives/2015/september/uber-gift.html accessed 17/5/2018

[148] Reuters (21/3/2016). One Year After Announcing Pact, the Uber-Carnegie Mellon Partnership Is Stalled. http://fortune.com/2016/03/21/uber-carnegie-mellon-partnership/ accessed 17/5/2018

money could make up at least for the short to medium run for the loss of that many members of the personnel.

In 2013, Facebook recruited[149] Yann LeCun, a leading AI scientist, from the New York University. However, he remained as a part time professor at NYU. In 2011 Andrew NG, was recruited from Stanford University by Google[150] and later on he was hired from Baidu. He remains as adjunct[151] professor at Stanford[152].

Gibney[153] (2016) through a series of short interviews argues that the decrease in the academic faculty personnel also leads to a decrease in the number of students to be trained . In addition, although there are professors that choose a joint role in both industry and the university, this role is minor. In the same context, the Economist [154]argues that the reduced university faculty would lead to inability to train the future researchers of the AI field.

Why academics go to the industry

The industry offers a package of salary and benefits that it's impossible for the academia to match. The extremely high salaries that are being paid to the skilled employees, which according to the NY Times[155] yields six digits salaries, is an indication of the lack of qualified employees. One of the biggest reasons for researchers to move from the public to the private sector are the salary and the various perks.

According to a research performed by Glassdoor[156], the biggest employers of AI related personnel (based on the actual job listings on Glassdoor) are big tech companies such as Amazon (13%), Nvidia (6%), Microsoft (4%), IBM (3%) and Accenture (3%).

The Glassdoor report clarifies that there are significant fluctuations in the salaries range and usually other perks and benefits are included in compensation packages such as stock options and bonuses. The company performed a research about the median basic salary (no

[149] https://research.fb.com/people/lecun-yann/ accessed 17/5/2018
[150]Nico Pitney (6/12/2017). Inside The Mind That Built Google Brain: On Life, Creativity, And Failure. https://www.huffingtonpost.com/2015/05/13/andrew-ng_n_7267682.html accessed 17/5/2018
[151] http://www.andrewng.org/ accessed 17/5/2018
[152] Andrew NG founded Coursera, a leading online platform that is open to all and offers education on many fields including AI . See https://about.coursera.org/ accessed 17/5/2018 and
[153] Elizabeth Gibney (26/4/2016). AI talent grab sparks excitement and concern. https://www.nature.com/news/ai-talent-grab-sparks-excitement-and-concern-1.19821 accessed 17/5/2018
[154] The economist (2/4/2016). Million-dollar babies. https://www.economist.com/business/2016/04/02/million-dollar-babies accessed 17/5/2018
[155]Cade Metz (22/10/2017). Tech Giants Are Paying Huge Salaries for Scarce A.I. Talent https://www.nytimes.com/2017/10/22/technology/artificial-intelligence-experts-salaries.html,
[156] Andrew Chamberlain(16/11/2017). Who's Hiring AI Talent in America? https://www.glassdoor.com/research/studies/ai-jobs/ accessed 17/4/2018

extras). "***The overall average[157] base pay for the AI jobs in our sample was $111,118 per year — more than twice the U.S. median base pay for full-time workers of $51,220 per year***".

Glassdoor reported that the majority of the open AI postings are placed in a few major urban areas such as Silicon Valley, San Francisco, Seattle, Boston, Los Angeles and NY city. Glassdoor company provided an analysis with the job title, the area and an average salary. The following table depicts the abundance of money paid by private corporations. The variety in the sectors where each employer is active, is indicative of the wide range of AI applications.

Top 15 AI Job Titles with Highest Pay

Job Title	Metro	Estimated Median Base Pay	Employer Industry
Director of AI	San Francisco	$257,269	Internet & Tech
VP of AI Product Management	San Jose	$249,500	Marketing & Advertising
Data Engineer for Deep Learning	San Jose	$243,623	Computer Software &Hardware
Attorney for AI Division	Los Angeles	$203,710	Internet & Tech
Deep Learning Engineer for Self-Driving Cars	San Francisco	$203,450	Consulting
Director of Marketing for AI	San Jose	$202,876	Manufacturing
Director of Machine Learning & AI	San Jose	$200,627	Computer Software & Hardware
Director of Technical Sales for AI	San Francisco	$190,098	Computer Software & Hardware
Director of Research for AI	Seattle	$188,966	Computer Software & Hardware
Software Engineering Lead for AI	Seattle	$186,435	Retail
Director of AI Product Management	San Francisco	$186,427	Internet & Tech
Senior AI Architect	San Francisco	$186,273	Banking & Financial Services
Head Scientist for Deep Learning	San Jose	$184,330	Farming & Agriculture
Applied Scientist for AI	San Jose	$183,843	Retail
Engineer for Deep Learning	San Francisco	$182,862	Manufacturing

Table 5: Source: Glassdoor Economic Research. Active unique job listings on Glassdoor with "artificial intelligence" or "deep learning" job titles as of October 20, 2017. Andrew Chamberlain(16/11/2017). Who's Hiring AI Talent in America? https://www.glassdoor.com/research/studies/ai-jobs/ accessed 17/4/2018

The CB insights[158] report posits that big technology firms lure the elite of AI personnel with competitive packages. At the same time however, the same research personnel leaves in order to create their own start-ups.

[157] Andrew Chamberlain(16/11/2017). Who's Hiring AI Talent in America? https://www.glassdoor.com/research/studies/ai-jobs/ accessed 17/4/2018

[158]CBInsights (2018), "top AI trends to watch in 2018". CBInsights

Biggest investors in AI talent	
Company	**Total Investment**
Amazon	$305,832,434
Microsoft	$124,062,524
Apple	$105,371,161
Alphabet (Google)	$33,567,049
Intuit	$28,344,107
Facebook	$22,948,321
NVIDIA	$22,295,391
Booz Allen Hamilton	$21,863,372
Oracle	$17,199,495
GE	$16,550,125

Highest paying companies	
Company	**AI engineer average salary**
1. Uber	$314,746
2. WalmartLabs	$265,698
3. Netflix	$264,799
4. Facebook	$257,846
5. Salesforce	$248,281
6. Google	$236,388
7. Coupang	$234,348
8. Twitter	$230,639
9. Splunk	$227,202
10. Apple	$227,094
11. Intuit	$221,438
12. Palo Alto Networks	$219,679
13. PayPal	$218,262
14. OpenTable	$215,399
15. VMware	$211,862
16. Amazon	$209,762
17. Unity Technologies	$208,729
18. Adobe	$207,076
19. eBay	$203,626
20. Veritas Technologies	$202,776

Tables 6 and 7: Source: Paysa (29/11/2017). New Paysa Study Reveals U.S. Companies Across All Industries Investing $1.35 Billion Dollars in AI Talent. https://www.paysa.com/press-releases/2017-11-29/11/new-paysa-study-r accessed 20/4/2018. Formatted by the author.

According to NY[159] Times, the salaries of AI researchers are extremely high even when it comes to nonprofit organizations like OpenAI. Neither the government nor the universities could offer the salaries provided by the industry. Specialists AI researchers with barely any experience could have yearly compensation ranging from 300.000-500.000 USD (stock and wage).

The company Paysa, offering HR and career services, published a report about the hiring trends in ai personnel for the period April to September 2017. The company published a list with the companies that spend the most money in AI personnel.

From the data presented, becomes apparent that there is much demand for AI personnel and very high salaries are offered. The candidates could search employment in a wide variety of sectors.

[159]Cade Metz (19/4/2018). A.I. Researchers Are Making More Than $1 Million, Even at a Nonprofit https://www.nytimes.com/2018/04/19/technology/artificial-intelligence-salaries-openai.html, accessed 21/4/2018

Furthermore, The MGI research paper 2017 states that big companies acquire the talented employees they need, besides the academics, through M&A. This method is known as the[160]"acqui-hiring". The companies acquire mainly the promising employees by buying the start-ups where they are employed.

NY[161] times in their article discuss the additional offer of shares to the AI executives on top of the lucrative salaries.

Other reasons

As discussed before, AI applications need an enormous amount of data in order to be trained. Only the big tech companies have access to this kind of DATA which are not available in the academia.

Furthermore, the industry offers an abundance of funding for the performing of research as well as state of the art equipment. The universities don't always have access immediately to the best equipment in the market. Or funding would have to be granted centrally for the equipment to be bought. All these usually require time and effort that in the industry would be spent in research.

In addition, in the industry the researchers get the chance to concentrate of their job without bureaucratic distractions.

Last but not least, the big corporations having hired the best AI scientists[162], in the field, could use them as recruiting baits for new employees.

7.2 Universities and the industry perform "different" kinds of research.

Academia and Industry have by default different missions and goals to accomplish. The industry usually focuses on applied research that could be quickly profitable. Academic research on the other hand focuses on a more basic level and has led to breakthroughs through the highly diverse research topics.

[160] McKinsey (MGI) report 2017, Artificial Intelligence: The Next frontier (2017) p. 11

[161] Cade Metz (22/10/2017). Tech Giants Are Paying Huge Salaries for Scarce A.I. Talent https://www.nytimes.com/2017/10/22/technology/artificial-intelligence-experts-salaries.html accessed 16/5/2018

[162] The economist (7/12/2017). Google leads in the race to dominate artificial intelligence https://www.economist.com/news/business/21732125-tech-giants-are-investing-billions-transformative-technology-google-leads-race

In the "100 year study on AI" report it is mentioned that the big tech companies such as Google and Facebook and IBM invest heavily in AI applications that "*they regard*[163] *as critical to their futures*".

Eric Larsen and Eric Schmidt[164] (2017) emphasized the importance of the government funding in universities and research centers to promote basic research. The authors celebrate the vibrant private sector of USA as well as the venture and start-up mentality, the latter of which often derive from basic research. However, they argue that only few companies engage in basic research. Basic research results are typically uncertain, unpatentable at early stages and inadequately commercialisable. According to the authors "*while investing in basic research typically*[165] *doesn't make sense for a business, it has been a winning strategy for our nation*". An example is given about previous academic research stimulated by neurons that led later to a major breakaway in the AI field.

This conclusion is supported by Jason Furman (2016) as well, who discusses the reduction of the federal government funding in R&D and its implications on scientific research. He mentions that while the industry[166] comprises around two third of total R&D expenditure, it is mainly used for applied research whereas the state funds 60% of basic research. Private corporations underinvest on it since there are no immediate gains. Deep learning was based on university research performed during the 80's and 90's funded at great extent by various federal agencies.

The EOP report[167] also posits that the basic research is underfinanced by the industry. The role of the basic research with the unique role of increasing knowledge, cannot be turned into profit for the paying corporation within a set timeframe.

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[163] Peter Stone, Rodney Brooks, Erik Brynjolfsson, Ryan Calo, Oren Etzioni, Greg Hager, Julia Hirschberg, Shivaram Kalyanakrishnan, Ece Kamar, Sarit Kraus, Kevin Leyton-Brown, David Parkes, William Press, AnnaLee Saxenian, Julie Shah, Milind Tambe, and Astro Teller. "Artificial Intelligence and Life in 2030." One Hundred Year Study on Artificial Intelligence: Report of the 2015-2016 Study Panel, Stanford University, Stanford, CA, September 2016. Doc: http://ai100.stanford.edu/2016-report. Page 6

[164] Eric S. Lander and Eric E. Schmidt (2017), (5/5/2017), America's 'Miracle Machine' is in desperate need of, well, a miracle. https://www.washingtonpost.com/opinions/americas-miracle-machine-is-in-desperate-need-of-well-a-miracle/2017/05/05/daafbe6a-30e7-11e7-9534-00e4656c22aa_story.html?utm_term=.e0dd218d5575. Accessed 13/5/2018. At the time the article was published, Eric E. Schmidt was the Executive Chairman of Alphabet, the parent company of Google.

[165] Eric S. Lander and Eric E. Schmidt (5/5/2017), America's 'Miracle Machine' is in desperate need of, well, a miracle.https://www.washingtonpost.com/opinions/americas-miracle-machine-is-in-desperate-need-of-well-a-miracle/2017/05/05/daafbe6a-30e7-11e7-9534-00e4656c22aa_story.html?utm_term=.e0dd218d5575. Accessed 13/5/2018

[166] Jason Furman (2016), "Is this time different? The opportunities and challenges of Artificial Intelligence", New York University. Page 10

[167] "Executive Office of the President (EOP) (2016), "Preparing for the future of Artificial Intelligence", page 25

In this context, the EOP report[168] (2016), lists a number of universities that have undertaken a number of initiatives to utilize AI technologies to address social issues. The University of Southern California has set up the USC center for artificial intelligence in the society (CAIS) which has the purpose of dealing with big societal problems. The center has been working[169] on issues relating to homelessness, the protection of wildlife etc. Stanford University on the other hand is working on using AI and satellite technologies[170] to tackle poverty.

The privatization of the AI research could affect negatively its originality and breakthrough ideas could be delayed or just lost. At the same time, the society is at loss since less research would be spent in addressing societal issues.

7.3 Implications for the economy and the local AI ecosystem

Ryan Kottenstette[171] (2018) comments that the constant and massive acquisition of startup companies by big tech companies, as discussed above in the TH model, deprives the society and the economy from diversified AI applications. The author claims that little actual progress has taken place related to AI in other sectors. The newly acquired/hired AI personnel is employed by tech companies and does not contribute towards the creation of AI solutions and products for others non-tech industry related challenges.

In addition, The Economist[172] highlights that the high salaries provided by the big companies set salaries standards that it very difficult to be achieved by smaller companies or start-ups. The big tech companies drain the US market from talented employees.

7.4 Non- Shared knowledge

As presented previously in the TH model section the US universities are quite productive in publishing papers related to AI research.

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[168] Executive Office of the President (EOP) (2016), "Preparing for the future of Artificial Intelligence", page 14

[169] Eric Rice and Milind Tambe (2017). USC Center for Artificial Intelligence in Society: Mission Statement. University of Southern California. https://www.cais.usc.edu/wp-content/uploads/2017/05/USC-Center-for-Artificial-Intelligence-in-Society-Mission-Statement.pdf accessed 13/5/2018

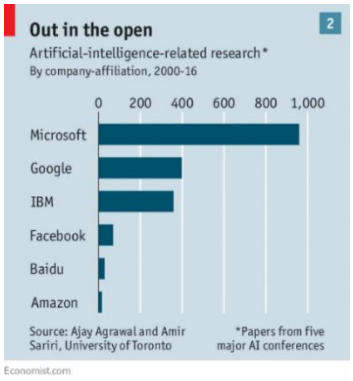
[170] Executive Office of the President (EOP) (2016), "Preparing for the future of Artificial Intelligence", page 14

[171] Ryan Kottenstette (2018), Silicon Valley companies are undermining the impact of artificial intelligence", https://techcrunch.com/2018/03/15/silicon-valley-companies-are-undermining-the-impact-of-artificial-intelligence/ accessed 15/5/2018

[172] The economist (5/11/2016). Tech firms shell out to hire and hoard talent https://www.economist.com/business/2016/11/05/tech-firms-shell-out-to-hire-and-hoard-talent accessed 5/4/2018

On the other hand, the publications of industry tend to be scarcer. The majority of the companies published few papers, but they have started increasing the number during the last years, especially due to the recruiting of academics that are interested in publishing.

According to the Economist[173], the number of published papers related to AI differ according to each company. The magazine presents the following graph for the period 2000-2016.



Graph 13. Source: https://www.economist.com/news/business/21732125-tech-giants-are-investing-billions-transformative-technology-google-leads-race (chart 2), accessed 11/5/2018

The graph shows the top companies that have published AI related papers. Microsoft, Google and IBM have published the majority of papers while the rest of the companies have published an extremely low number of papers. Amazon[174] and Apple are highly secretive concerning their research. The same applies to other firms in the field.

Since 2016, Google has increased the publishing of research papers. According to Fortune[175] companies such as Google, Facebook and Microsoft have created blogs where they publish and discuss the progress of their AI research and its use. We can conclude that research and knowledge in the industry is kept to a high degree from the public from certain companies.

The US EOP in one[176] of its 2016 AI related papers reports that the greatest part of AI basic research is conducted by academia and commercial labs and is being published.

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[173] The economist (7/12/2017). Google leads in the race to dominate artificial intelligence https://www.economist.com/news/business/21732125-tech-giants-are-investing-billions-transformative-technology-google-leads-race accessed 11/5/2018

[174] The economist (7/12/2017). Google leads in the race to dominate artificial intelligence https://www.economist.com/news/business/21732125-tech-giants-are-investing-billions-transformative-technology-google-leads-race accessed 11/5/2018

[175] Jonathan Vanian (19/7/2017). Apple Just Got More Public About Its Artificial Intelligence Plans http://fortune.com/2017/07/19/apple-artificial-intelligence-research-journal/ accessed 12/5/2018

[176] Executive Office of the President (EOP) (2016), "Preparing for the future of Artificial Intelligence", page 24

Professor Andrew NG in one of his interviews[177] highlighted the importance of openness in AI research and indicated how this openness is undermined by AI researches who publish their findings but withhold crucial technical details.

Gibney[178] (2016) also cites interviews where concerns are raised about the secrecy of corporate researchers and their reluctancy to reveal parts of their research before the publication date of it, possibly due to pending patent applications.

The economist[179] specifically discusses that the AI expertise is unequally gathered in only a few firms where "*in practice, however, many profitable findings are not shared*".

Hoadley and Lucas (2018)[180] discuss also the barriers that exist in certain collaborations between the government and the industry in sharing technology. One of the reasons is that the industry is interested in short term profits whereas the government has a longer-term horizon. In addition, the private companies are very protective of their intellectual property rights. The industry provides the government with specific AI applications but not the code, which is necessary to understand how the technology works.

Archibugi and Filippetti (2018) also highlight that the corporations generally make use of various different ways such as IPR to avoid the circulation of their privately produced knowledge to their competitors. They argue that this is one of the many differences between publicly produced knowledge (that includes the universities) which is freely distributed and knowledge produced in industry, which is protected so as to discourage and prevent imitation and replication. However, companies are open towards the dissemination of their knowledge when they follow the open innovation model.

Thus, the privatization of research leads to less knowledge becoming public. The secrecy doesn't help the acceptance of AI which has had previous issues with hidden biases and lack of transparency since it was unable to explain how it reached specific results.

[177] Lisa Eadicicco(11/1/2017). He Helped Create the 'Google Brain.' Here's What He Thinks About AI Now.http://time.com/4631730/andrew-ng-artificial-intelligence-2017/ accessed 12/5/2018

[178] Elizabeth Gibney (26/4/2016). AI talent grab sparks excitement and concern https://www.nature.com/news/ai-talent-grab-sparks-excitement-and-concern-1.19821

[179] The economist (2/4/2016). Million-dollar babies. https://www.economist.com/business/2016/04/02/million-dollar-babies accessed 17/5/2018

[180] Daniel S. Hoadley, Nathan J. Lucas (2018) "Artificial Intelligence and National Security", Congressional Research Service, CRS Report, https://fas.org/sgp/crs/natsec/R45178.pdf, page 16

7.5 Consolidation of industry and lack of regulation

The Artificial Intelligence and National Security[181] report discusses that the federally financed research during the previous decades has led to major defence related technological milestones such as the Internet, GPS and nuclear technology. The research was initiated by the government and was later developed further by the universities and commercialized by the companies. However, in the AI field, which is of crucial importance, research is being led by a "relatively small number of companies"; the companies develop commercial applications that are then adjusted to serve military purposes. The report[182] highlights that the US government saves money by relying to the AI R&D provided by the industry.

The collaboration between Industry[183] and government according to the report is considered to be poor.

The "100 year study on AI" report highlights the danger that AI technology could widen instead of diminishing the social inequalities if it is unequally distributed and accessed by parts of the society. Debates will arise concerning the distribution of the new wealth produced by AI, especially since the relevant expertise as well as the data that support it are in the hands of few big firms. AI technologies and the BIG data used to support them could include many different kinds of biases, just as Cathy 'o Neil and many other authors have described. There is a high degree of consolidation in the AI market, as the big companies are few and they keep acquiring the smaller ones.

The "100 year study on AI" report discusses the lack of adequate regulatory supervision of the big tech companies. As AI applications evolve new challenges and ethical questions arise which need to be addressed within a proper regulatory framework which however won't suffocate innovation. Questions such as protection of privacy, unbiased decisions reached by AI algorithms, liabilities issues in case of autonomous cars' accidents etc. need to be addressed. The AI100 report highlights the importance of AI as a mean to increase the value for the entire society. This entails the notions of openness and fairness and security and privacy.

[181] Daniel S. Hoadley, Nathan J. Lucas (2018) "Artificial Intelligence and National Security", Congressional Research Service, CRS Report, https://fas.org/sgp/crs/natsec/R45178.pdf, page 13
[182] Daniel S. Hoadley, Nathan J. Lucas (2018) "Artificial Intelligence and National Security", Congressional Research Service, CRS Report, https://fas.org/sgp/crs/natsec/R45178.pdf, page 13
[183] Daniel S. Hoadley, Nathan J. Lucas (2018) "Artificial Intelligence and National Security", Congressional Research Service, CRS Report, https://fas.org/sgp/crs/natsec/R45178.pdf, page 16

FitzGerald and Parziale (2017) also discuss the disruptive nature of AI into economy and the society and the uncertainty that there is regarding which technologies will be developed and which and when will prevail. They emphasize the inability of national governments and international organizations to protect the society from the dangers of powerful AI technologies, as they have little influence on their development.

FitzGerald and Parziale (2017) comment further on the fact that Silicon Valley companies are unwilling or unable to undertake responsibility for the negative implications of their products. Examples used include the spread of fake news via Facebook and UBER releasing its fleet of autonomous cars in San Francisco streets without having applied for a permit. As mentioned before in this paper, the Facebook Analytica scandal is one of the latest in a row of AI cases gone bad. Although, aside from Facebook's responsibility is of equal importance the fact that the politicians[184] were the ones that took advantage of it.

In addition , the "100 year study on AI" [185] report refers to the lobbying activities of these few big companies to avoid being regulated by the state as this would impact on their innovation activities and the development cycles of their products. The highly intense lobbying efforts of the big tech firms such as Google[186], Amazon[187], Apple and Facebook are frequently reported and commented upon by the press. The Information Technology Industry Council (ITIC), which represents the interests of the American industry in various issues published in 2017 "AI policy principles" where they advocate the right of the corporations not to disclose various elements of their intellectual property. It is specifically mentioned that "*To this end, we believe governments[188] should avoid requiring companies to transfer or provide*

[184] The Cambridge Analytica scandal refers to facilitating the election of the current president of USA. Whereas the previous one has also said that he relied on the use of social media to promote his political career. BIG DATA and algorithms were utilized to promote his campaign in 2012. (see Antony Ha (12/1/2018). As David Letterman's first Netflix guest, Barack Obama warns against the 'bubble' of social media https://techcrunch.com/2018/01/12/as-david-lettermans-first-netflix-guest-barack-obama-warns-against-the-bubble-of-social-media/ and Sasha Issenberg (18/12/2012). Obama's Data Techniques Will Rule Future Elections. https://www.technologyreview.com/s/508856/obamas-data-techniques-will-rule-future-elections/ both accessed 17/5/2018)

[185] Peter Stone, Rodney Brooks, Erik Brynjolfsson, Ryan Calo, Oren Etzioni, Greg Hager, Julia Hirschberg, Shivaram Kalyanakrishnan, Ece Kamar, Sarit Kraus, Kevin Leyton-Brown, David Parkes, William Press, AnnaLee Saxenian, Julie Shah, Milind Tambe, and Astro Teller. "Artificial Intelligence and Life in 2030." One Hundred Year Study on Artificial Intelligence: Report of the 2015-2016 Study Panel, Stanford University, Stanford, CA, September 2016. Doc: http://ai100.stanford.edu/2016-report., page 43-44

[186] The economist (18/5/2017). When bosses visit the White House, their firms make more money.https://www.economist.com/business/2017/05/18/when-bosses-visit-the-white-house-their-firms-make-more-money accessed 18/5/2018

[187] Cecilia Kang, Thomas Kaplan and Nicholas Fandos (12/4/2018). Knowledge Gap Hinders Ability of Congress to Regulate Silicon Valley. https://www.nytimes.com/2018/04/12/business/congress-facebook-regulation.html accessed 19/5/2018

[188] ITIC (2017), "AI policy principles Executive summary" (24/10/2017), page 4 http://www.itic.org/dotAsset/50ed66d5-404d-40bb-a8ae-9eeeef55aa76.pdf

access to technology, source code, algorithms, or encryption keys as conditions for doing business".

As presented in the introduction, the AI has multiple applications to almost all aspects of everyday life.

The privatization of research by companies that do not want to be open about their work and fight to remain unregulated, could inflict considerable damage to the society and the economy. This damage could be irreversible in the case of AGI.

7.6 Ethics and Risks

AI can have both advantages and disadvantages for the humanity. Given the unprecedent state of advances in the AI technologies one can easily see the benefits, however the possible dangers are not always possible to be described. The report[189] on the malicious use of AI attempts to put on paper all the things that could possibly go wrong with AI and provides some solutions in order to mitigate the risks.

The AI Now 2017 report by the AI Now Institute emphasizes the importance of ethics for AI, especially when various AI technologies will be used to take decisions regarding human lives. According to the report the formation of ethical values to be incorporated in AI has never been an easy task. The report states that when trying to answer these kind of challenges, it is important to examine both the power relations concerning the process of developing and advancing AI technologies as well how the decision-making processes of both the creators of these systems and the AI systems are often kept hidden and are unaccounted for.

Crawford and Calo (2016) discuss the flaws in the current adoption of several AI systems in many sectors from doctors to judges. The AI systems are being applied without having first being evaluated on their social context. One such algorithm that was used by the judges in USA courtrooms in order to estimate the risk of criminals to relapse was heavily prejudiced against black people. The authors of the article conclude that the majority of the solutions to such challenges have been so far been ad hoc, after the algorithms have been tested or

[189] Brundage, Miles; Avin, Shahar; Clark, Jack; Toner, Helen; Eckersley, Peter; Garfinkel, Ben; Dafoe, Allan; Scharre, Paul; Zeitzoff, Thomas; Filar, Bobby; Anderson, Hyrum; Roff, Heather; Allen, Gregory C.; Steinhardt, Jacob; Flynn, Carrick; hÉigeartaigh, Seán Ó; Beard, Simon; Belfield, Haydn; Farquhar, Sebastian; Lyle, Clare; Crootof, Rebecca; Evans, Owain; Page, Michael; Bryson, Joanna; Yampolskiy, Roman; Amodei, Dario (2/2018). "The malicious use of artificial intelligence: Forecasting, prevention and mitigation". Future of Humanity Institute, University of Oxford, Centre for the study of Existential risk, University of Cambridge, Center for a New American Security, Electronic Frontier foundation, Open AI. https://img1.wsimg.com/blobby/go/3d82daa4-97fe-4096-9c6b-376b92c619de/downloads/1c6q2kc4v_50335.pdf

released. They propose the promotion of a holistic view of AI systems, through their social, political, economic impact and with the contribution of various stakeholders. Examples of big misuses have been described in detail in Weapons of Math destruction (determination of recidivism rates, inability to explain how the result of the algorithm was reached) , and although many of these biased/misfunctioning algorithms were eventually corrected, some people had actual damages of social or economic nature.

The report about the malicious uses[190] of AI also reaches the above conclusion. Due to the fact that AI can easily be used both for good and evil purposes, a public dialogue is proposed to be initiated between all possible stakeholders such as AI researchers, the industry, the public, ethicists, policymakers on the suitable and society beneficial use of AI.

The previous misuses of algorithms could be interpreted as products that were released in the commerce before their safe and proper operation was verified. A part of the society had to live with the consequences before the biases were spotted and addressed. The fast circulation of these products/services creates considerable doubts as to whether the private firms can self-restrain and place society's benefit above their profit.

The privatization of the AI research in combination with the difficulties in incorporating ethics into AI and the inability/unwillingness of tech firms to be regulated pose significant challenges concerning the efficiency of the current AI system and finding the best solutions for the society.

7.7 Impact on local/national innovation systems.

The privatization of the research enters directly in the field of universities. The analysis of the Triple helix system describes the lead role of the university in the innovation both locally, (we presented important AI hubs built around internationally famous universities) as well as nationally. The universities are an important pillar in the triple helix model which is a key to the innovation in regional and national level.

[190] Brundage, Miles; Avin, Shahar; Clark, Jack; Toner, Helen; Eckersley, Peter; Garfinkel, Ben; Dafoe, Allan; Scharre, Paul; Zeitzoff, Thomas; Filar, Bobby; Anderson, Hyrum; Roff, Heather; Allen, Gregory C.; Steinhardt, Jacob; Flynn, Carrick; hÉigeartaigh, Seán Ó; Beard, Simon; Belfield, Haydn; Farquhar, Sebastian; Lyle, Clare; Crootof, Rebecca; Evans, Owain; Page, Michael; Bryson, Joanna; Yampolskiy, Roman; Amodei, Dario (2/2018). "The malicious use of artificial intelligence: Forecasting, prevention and mitigation". Future of Humanity Institute, University of Oxford, Centre for the study of Existential risk, University of Cambridge, Center for a New American Security, Electronic Frontier foundation, Open AI. Page 52.

Jennings[191] (2018) accentuates the importance of research universities as the center of AI innovation hubs. The combination of academic faculty, inspired students and university start-ups are the base for truly innovative and diverse technologies, which often focus on what is beneficial to the society and not what will be simply profitable.

The greatest rival of the USA, at the moment, in the race of AI is China, which contrary to the USA invests heavily in universities. On the 20th of July 2017, the Chinese government issued a document called "A next generation artificial intelligence development plan", where it stated its priorities and plans for the national growth of the AI field up to 2030. In this plan, among other things, the Chinese government highlights[192] the importance of universities and their role in the innovation process and commits into cultivating the AI academic discipline by, among others, establishing AI institutes, increasing the number of students' places in AI related study fields, increasing AI and related field courses of all levels offered by universities, colleges etc.

Conclusion

The privatization of research is a phenomenon that has caused concerns for a number of reasons which are summarized in the following table.

Concerns regarding:
Brain flight to industry: lack of teaching staff
Different research performed in academia and the industry (socially oriented/ basic/ applied)
Production of knowledge that is not shared entirely
Big companies drain the experts from the market
Few big players and lack of regulation
Ethics and risks
Impact on local/national innovation system

Table 8

The disruptive effect that AI is having and could have in the future in the economy and the society in combination with a) the examples of misuse of AI and BIG DATA presented previously and b) the lack of regulatory framework form the base for reasonable concerns.

[191] Nick Jennings (5/4/2018), Universities must stay at the heart of the AI revolution. Here 's why". https://www.weforum.org/agenda/2018/04/universities-must-stay-at-the-heart-of-the-ai-revolution-heres-why/ accessed 20/4/2018

[192] The original document is in Chinese. The translation of the original document to English was performed by New America. State Council Notice on the Issuance of the Next Generation Artificial Intelligence Development Plan (2017). Page 14. See Graham Webster, Rogier Creemers, Paul Triolo, and Elsa Kania (1/8/2017). China's Plan to 'Lead' in AI: Purpose, Prospects, and Problems. https://www.newamerica.org/cybersecurity-initiative/blog/chinas-plan-lead-ai-purpose-prospects-and-problems/ page 14.

8. Discussion

The role of the University

This section is part of the discussion of what could be the role of the university in the changing AI system. In these challenging times, the teaching mission of the university is crucial in preparing the students and the society for the changes that are coming. The third mission of the university will be also addressed. The significance of the introduction of courses in ethics and human rights along with the need to broaden the diversity of AI staff will be argued. Furthermore, suggestions concerning the navigation of the university in its collaborations with the industry and the government will be made.

The three missions of the university

AI technologies are crucial for the future of the economy and the society and even though the development of AGI (Artificial General Intelligence) might not be a short-term problem even the current ANI applications pose serious concerns and challenges for the future that need to be addressed taking into consideration the best interests of all stakeholders affected (society, industry, government).

Currently USA are leading the AI race. The previous analysis emphasized the leading role of the industry in the AI in the USA and the inability/denial of the government to regulate the field that considers to be a huge competitive advantage. The role of the university becomes more eminent as it is called to keep the balances in the system, protect its own function and the interests of the society as well.

The prominent role that the university has undertaken has been described by the term "third mission", which is not strictly defined. Rubens et al (2017) mention that the third mission of the universities entails but is broader that the entrepreneurial university notion. The universities traditionally have had two missions: teaching and research. The third mission is related to a diverse range of activities that are not included within the first two. According to the ε3m report "*Third mission activities*[193] *are concerned with the generation, use,*

[193] E3M-Project. 2012b. Needs and Constraints Analysis of the Three Dimensions of Third Mission Activities. http://www.e3mproject.eu/docs/Three-dim-third-mission-act.pdf., page 20 (conclusions chapter). See also Molas-

application and exploitation of knowledge and other university capabilities outside academic environments. That is, third mission activities focus on the interactions between universities and the rest of society that add, and to some extent overlap, to the traditional first (teaching) and second (research) university missions, instead of being considered as residual activities. Consequently, third mission activities are related to research (technology transfer and innovation), teaching (lifelong learning/continuing education) and social engagement in line with regional/national development".

The definition, although long, has been cited here to illustrate better what the third mission is and how it is connects to the teaching and research. The definition shows that the university is called to avoid the so called "ivory tower" of isolation of academics and engage both with the industry, the government and the society. The E3M green paper[194] (2012) emphasizes that through the third mission the university will communicate and collaborate meaningfully with the society in a variety of forms.

According to Pinheiro et al (2015) in the knowledge-based economy, the universities have a continuously more crucial part to play towards the promotion of economic development and social advance. The engagement of academics in various third mission activities is different according to the discipline, the university, the country.

The entrepreneurial activities of the university and its interactions with the industry and the government have been analyzed above. The discussion that follows consists of guidelines towards the university of how to navigate its course in the changing AI system while at the same time introducing proposals that address the civil society as well. In other words, in this part will be discussed the role that the university could undertake with its three missions in the shifting AI system given the conditions that were described in the TH model in all three.

8.1 Introducing ethics and human rights studies in the universities.

The IEEE[195] discusses the disruptive effect of AI in the society and the economy currently as well as the future issues that could arise. It acknowledges that as research progresses,

Gallart, J., Salter, A., Patel, P., Scott, A. and Duran, X. (2002), Measuring Third Stream Activities: Final Report of the Russell Group of Universities , SPRU Science and Technology Policy Research Unity, University of Sussex

[194] E3M-Project. 2012a. Green Paper-Fostering and Measuring 'Third Mission' in Higher Education Institutions. http://www.e3mproject.eu/docs/Green%20paper-p.pdf.

[195] IEEE stands for the Institute of Electrical and Electronics Engineers. See ieee.org. The organization has prepared a report as a basis for public discussion by various stakeholders in order to promote The IEEE Global Initiative for Ethical aligned Design.
The IEEE Global Initiative for Ethical Considerations in Artificial Intelligence and Autonomous Systems.

people will be met with continuously more complex issues regarding ethical decisions and safety challenges as AI applications will become gradually more autonomous and multitasking.

Students of computer and related sciences

The IEEE report recognizes[196] that there is lack of ethics courses in engineering and technological studies. In addition, AI scientists fail to acknowledge the ethical issues that are inherent in their technical work. According to Burton et al (2017) engineer studies include usually some courses concerning professional ethics. This usually entail minimum principles that govern one's personal and professional conduct in his business environment. Burton highlights that ethics need to be expanded since the engineered AI products are or will be able to decide autonomously e.g. the possible use of robots in war. The authors consider that the proper ethics training will provide the designers of AI systems with the possibility to see their work through many different angles and facilitate them in acknowledging the responsibilities, dangers and possibilities of their systems. Ethics perspective needs to be taken in account when designing the AI systems.

The World Economic Forum's WHITE PAPER (2018) highlights specifically the need for the researchers of AI to be fully familiar with human rights and obligations and to abide by the principle of non-discrimination.

Thus, courses about ethics and human rights need to be obligatory part of the studies of all technological fields. The need for ethical reflection on the sequences of everybody's work, current or future, has always been important but becomes even more necessary in front of the possible AI dangers.

Law students

The incorporation of ethics in the AI is a difficult challenge that needs to be addressed. It is not easy even to define ethics.

The early deployment of AI applications has already led to the rise of significant legal issues. Examples are the recent Cambridge Analytica scandal and who bears responsibility, who has accountability for biases incorporated into algorithms, who has liability in case of an accident

Ethically Aligned Design: A Vision For Prioritizing Wellbeing With Artificial Intelligence And Autonomous Systems, Version 1. IEEE, 2016. http://standards.ieee.org/develop/indconn/ec/autonomous_systems.html.

[196] The IEEE Global Initiative for Ethical Considerations in Artificial Intelligence and Autonomous Systems.(2016) Ethically Aligned Design: A Vision For Prioritizing Wellbeing With Artificial Intelligence And Autonomous Systems, Version 1. IEEE. http://standards.ieee.org/develop/indconn/ec/ead_v1.pdf page 10

caused by and autonomous driven car etc. There is a dire need for AI related courses to be incorporated in the curriculum of the law schools around the world. The IEEE report highlights[197] that practicing lawyers and academics have not responded adequately to the current challenge posed by AI so far.

All other students

AI courses need to be incorporated in all classes. The majority of people today do not understand what AI actually is. Pega[198] contacted a global research concerning consumer's knowledge of Artificial intelligence; it revealed that only 33% of the interviewees replied that they had ever used AI applications whereas in reality 84% of these people had recently interacted with an AI application such as google search, spam filters etc.

The society

Given the effects of AI, all people need to be informed about AI and its consequences. AI courses need to be introduced to all education levels. The university needs to incorporate AI courses that are not technical but explanatory to all faculties. Crawford[199] and Calo (2016) discuss the need for a holistic approach to AI. This can only be achieved if all stakeholders are educated on AI issues.

The universities could also organize free informative events to educate the citizens that do not have access to official education on basic AI issues. The US EDP report[200] argues that an AI driven environment requires "*data-literate*" citizens, who will be able to interact and deploy efficiently with various data and participate in AI related debates.

8.2 Academic research to keep addressing social issues

As discussed in the TH model, the bulk of AI research is performed by the industry and the universities. The industry's refusal to be regulated along with many examples of misuse of AI applications reveal its reluctancy to place social safety and benefit before profit. This of course

[197] The IEEE Global Initiative for Ethical Considerations in Artificial Intelligence and Autonomous Systems. Ethically Aligned Design: A Vision For Prioritizing Wellbeing With Artificial Intelligence And Autonomous Systems, Version 1. IEEE, 2016. http://standards.ieee.org/develop/indconn/ec/autonomous_systems.html. page 10.
[198] Pega (2017), What Consumers really think about AI: A global study", page 7. https://www1.pega.com/system/files/resources/2018-05/what-consumers-really-think-about-ai-study.pdf
[199] Kate Crawford and Ryan Calo (2016), There is a blind spot in AI research, Nature vol 538, pages 311-313
[200] Executive Office of the President (EOP) (2016), "Preparing for the future of Artificial Intelligence, page 27

is not always the case but given the extend of the consequences of AI applications, the outcomes could be detrimental to parts of the society and usually to the already most sensitive one (minorities, underprivileged groups etc.). On the other hand, the academic research is not driven by the achievement of short term profit but usually by the effort to extend scientific knowledge.

It is vital that the academics continue to address with their research social issues, which are usually overseen by the industry unless profits can be achieved.

8.3 Providing AI education to the policy makers

The Cambridge Analytica scandal was a first sign that the big tech companies might not be able to self-regulate and political intervention will be needed. However, the regulators need to be able to understand the new technologies. When Facebook CEO M. Zuckerberg was called to testify in the congress, the process revealed that some of the congress members[201] were unable to understand the company's business model. As technology advances, newer and technologically complex products/applications will enter the market and the policymakers need to be in position to understand them before they regulate them.

The university could serve as a counsellor and could also provide fast track education to the policymakers. It should be obligatory for independent professors of specific fields to participate in committees where issues related to their field of expertise are being discussed.

Finally, one should always take into account that political will is required for regulations to be drafted and voted. Since the university educates the politicians as well, it is vital to keep its graduates close by engaging them in various activities. The Alumni groups could be upgraded and their ties with the universities should be strengthened. The university could intensify the building of local formal/informal communities with the participation of policymakers for the discussion of AI related and other issues.

[201] Margaret Sullivan (10/4/2018).Members of Congress can't possibly regulate Facebook. They don't understand it. https://www.washingtonpost.com/lifestyle/style/members-of-congress-cant-possibly-regulate-facebook-they-dont-understand-it/2018/04/10/27fa163e-3cd1-11e8-8d53-eba0ed2371cc_story.html?noredirect=on&utm_term=.ef6d7336c4b9 and Cecilia Kang, Thomas Kaplan and Nicholas Fandos (12/4/2018). Knowledge Gap Hinders Ability of Congress to Regulate Silicon Valley https://www.nytimes.com/2018/04/12/business/congress-facebook-regulation.html accessed 19/5/2018

8.4 Diversity of AI personnel

Issues have arisen due to the lack of diversity in the AI workforce. The US EOP report[202] mentions that the percent of female computer scientists graduates has fallen considerably through the years instead of increasing and it below 20%.

Crawford[203] (2016) argues that the biases that have been inflicted on AI applications depict the biases of their creators. One of the examples describes that Google was less likely to present to women advertisements for highly paid jobs. Bass and Huet[204] (2017) emphasize that women and minorities are the biggest biased against groups in AI. Algorithms learn and grow as more and more data are provided. However, if the data are biased, there will be heavy consequences. And whereas today, these biases are being discovered and resolved due to human intervention, if some of these biases remain undetected in a future time when the AI systems will be autonomous and unsupervised, the results could be detrimental. Bolukbasi et al (2016) discuss the biases that are embedded in words like associating more women with the terms the homemaker or nurse and men with the terms programmer. They argue that even though the data depict the reality which is biased, and that it would be better to fix these inequalities in the society first, they hope[205] that by reducing the biases in the computer systems will maybe help the situation in society to improve as well; machine learning should most definitely not serve as means of augmenting these biases out of proportions.

The EOP report[206] stresses that one key step towards eliminating some algorithmic biases is, among others, the increase of diversity and inclusion in STEM and especially in the AI field. There is need to extend the pool of candidates into groups that are currently underrepresented. The inclusion of people in the AI personnel[207] from different backgrounds and diverse experiences would help to steer away from a narrow AI growth and detect early on and avoid biases.

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[202] Executive Office of the President (EOP) (2016), "Preparing for the future of Artificial Intelligence"

[203] Kate Crawford (25/6/2016). Artificial Intelligence's White Guy Problem. https://www.nytimes.com/2016/06/26/opinion/sunday/artificial-intelligences-white-guy-problem.html. accessed 11/5/2018.

[204] Dina Bass and Ellen Huet (2017), "Researchers combat gender and racial bias in artificial intelligence", Bloomberg https://www.bloomberg.com/news/articles/2017-12-04/researchers-combat-gender-and-racial-bias-in-artificial-intelligence accessed 21/5/2018

[205] Tolga Bolukbasi, Kai-Wei Chang, James Zou, Venkatesh Saligrama, Adam Kalai (2016), Man is to Computer Programmer as Woman is to Homemaker? Debiasing Word Embeddings, https://arxiv.org/abs/1607.06520 accessed 21/5/2018

[206] EOP (2016), Artificial Intelligence, Automation, and the Economy", page 3

[207] Executive Office of the President (EOP) (2016), "Preparing for the future of Artificial Intelligence, page 28

The AI Now 2017 Report also emphasized how the biases found in AI systems depict the issues of lack of inclusion of women and minorities and their representation.

Thus, the universities would need to step up and increase the enrolment places available to women and other underrepresented groups. The introduction of minimum rates that would grow each year until a balance is reached would be a good start. The university is the first step as without proper college/university education people cannot really find a job in the STEM sector.

8.5 Academia- Industry collaboration

There has been extensive research concerning the collaborations between the university and the industry specifically. The TH model that was presented before analyzes this relation as well. In the AI field, one could also use the absorptive capacity model (Zahra and George, 2002) to interpret parts of the research privatization issue. The corporations are close to universities and drain their personnel in order to increase their absorptive capacity.

Absorptive capacity is defined as "*the ability to value, assimilate and apply new knowledge (Cohen and Levinthal 1990)*[208]". Carayannis et al. (2000) discuss that through the collaboration between the three helixes, each helix has different objectives, different absorptive capacity each and different knowledge base, thus at the end of the each one will disseminate and use the common knowledge differently internally.

The big tech industries gain access to new knowledge by recruiting important employees directly. Previously was mentioned the example of UBER that hired almost one fourth of Carnegie Mellon's Lab personnel. Furthermore, the firms participate in seminars and conferences and finance university research in order to be aware of new advances. The establishment of corporate research centers in proximity or in collaboration with universities serve the purpose of the firms tapping into exogenous knowledge. The acquired knowledge is then assimilated and transformed/converted into specific products that will be commercially exploited. The big tech firms are already in possession of prior knowledge and have the appropriate structures to make the most out of the newly acquired knowledge. The AI field is an exquisite example of corporate absorptive capacity given all the applications such as internet, gps, autonomous cars etc. that started from research and then where commercially

[208] Zahra, Shaker A. and GEORGE, Gerard. Absorptive Capacity: A Review, Reconceptualization, and Extension. (2002). Academy of Management Review, vol 27, no 2 p 185-203, page 188

extremely successful. The collaboration of university and industry has been cultivated for many years. The industry taps into the basic research that the university performs. According to Pohulak- Zoledowska (2014), the role of basic research is to advance the knowledge and to engage in the solving of purely scholar problems that have no direct commercial implications. Freitas et al (2013) analyse two distinct types of academia-industry collaboration regarding the transfer of knowledge. The first type refers to the co-existence of researchers from both institutions in common networks, both social and professional. The second type refers to the structured transfer of knowledge through the development of structures such as technology transfer offices. A thorough review of literature regarding the collaborations between university and industry was conducted by Ankrah and AL-Tabbaa (2015).

The collaboration between industry and universities in the AI field takes all the forms summarized by Ankrah[209] and AL-Tabbaa (2015): personal informal relationships (such as informal networking through conferences, publications, joint or individual lectures, academic spin-offs), personal formal relations (such as scholarships, sabbaticals of professors and students, recruiting of various scientists in the corporations, industrial funding of Phds), third party (technology transfer departments in universities, industrial and academic liaison offices, intervention of governmental departments), Formal targeted agreements (such as collaborative research projects, training programs for corporate employees), formal non targeted agreements (eg corporate funding of research in university, research gifts and donations) and focused structures (such as the creation of labs for cooperation of industry and university, technology parks, association parks etc).

Addressing specific issues

The privatization of research bears great challenges for the universities since it affects among others their personnel. As discussed previously, the industry has been recruiting highly successful and knowledgeable professors and researchers from the universities. Perkmann et al (2013) discuss that male academics are more likely to engage with the industry. Furthermore, experienced academics have more extensive networks which make easier an approach by the industry. Perkmann et al (2013) highlight also that the brightest and most successful academics interact mostly with the industry. This is the case in the AI field.

[209] Samuel Ankrah and Omar AL-Tabbaa (2015), Universities-industry collaboration: A systematic review", Scandinavian Journal of Management (2015) 31, 387—408. Page 391 table 1.

It should be noted though, that the corporations understand and value the high quality of research performed by the universities; academia should face industry as an equal and bargain for benefits that would upgrade its status in the society.

Double employment

The big difference in the salaries and various perks provided by the industry in combination with the limited supply of qualified and trained AI personnel, mean that the brain drain is not going to stop in the short term. The universities need to take that into consideration in their hiring plans. It is doubtful that the universities would be able to pay that high salaries. Instead they could promote the mixed status that are already used by some professors. Such an example is Andrew Ng, who retains his position as a professor at Stanford while at the same time working for the private sector and running his own companies.

Since the university cannot avoid these situations it should at least try to make the most out of them. The professors could act as an additional connecting link of knowledge transfer from the industry to the university. The students could be offered internships to these companies or summer positions in order to gain knowledge of the industry. Once the internships/collaboration in joint industry academia is completed, the students should be required to report on their experience regarding the code of conduct and ethics approach that was followed in the specific company. This interaction and discussion in the universities can raise awareness about the level of standards/ practices in the industry and how these could be improved. The university could truly contribute to AI research and to the future of humanity by instilling to its students the need to always consider the ethical view of their work. Academics that work for the private sector are perfectly fit to emphasize the differences in the approach and the culture on ethics between the corporations and the academia.

Access to data

One of the main reasons of entering into a collaboration is to gain access to each other's assets that have been so far unshared. The university lacks access to the BIG DATA, that are so abundantly available to the big tech companies. The university could benefit by requiring the access to the BIG DATA that are available during the joint projects with the industry, to be extended to other research projects of the university. The data would be anonymized and handled with the strictest privacy rules.

Furthermore, the university could press the USA government to realize its proposal[210] concerning the "*Federal agencies to prioritize open training data and open data standards in AI*".

Ignite the discussion about the standards

The AI sector in the USA is unregulated and the firms have fought intensively to achieve this. In addition, the US NSTC strategic plan about AI R&D acknowledges the need to establish methodologies to guarantee the consistent performance of AI technologies that would increase their safety and transparency. The university could emerge as the link that will work intensively and lead both the state and the industry into developing industry standards. The university is the ideal actor to push and promote the development of this, since it employs experts from various faculties e.g. professors and personnel in ethics, philosophy, sociology, engineering, AI, history, anthropology, medicine etc. Internal committees could be formed that would address major AI issues such as accountability, safety and containment of AI systems. Furthermore, the ties between the government and the universities are tight, due to the governmental funding of public research. According to the US EOP (White House) report[211], the government plans to intensify its ties with academia in order to keep abreast with the latest technological developments in the AI sector. It is up to the university to highlight the risks to the government and demand changes in the regulation. The US NSTC (White House) in its National AI R&D strategic plan[212] discusses exactly the importance of academia, users and industry in setting the standards and benchmarks for the AI industry. The universities should collaborate and lead the way.

Choice of research

Gibney[213] (2016) cites Geoffrey Hinton predicting that the shortage in personnel that works with machine learning will be temporary. It should be taken into account[214] that India and China have many STEM students and invest heavily in teaching AI to students.

The industry recognizes the importance of academia in the research and this is depicted by the close collaboration between the two as discussed previously. Examples include: Uber

[210] Executive Office of the President (EOP) (2016), "Preparing for the future of Artificial Intelligence
[211] Executive Office of the President (EOP) (2016), "Preparing for the future of Artificial Intelligence
[212] NSTC, Networking and Information Technology Research and Development Subcommittee (2016), The national artificial intelligence research and development plan, Office of Science and Technology Policy, page 34
[213] Elizabeth Gibney (2016), AI Talent grab sparks excitement and concern, nature news, springer news, vol 532
[214] Scott Maxwell (24/4/2017), Why the AI Brain Drain Won't Last. https://www.inc.com/scott-maxwell/why-the-ai-brain-drain-wont-last.html

donated 5.5 million dollars to Carnegie Mellon University, Google[215] is funding academic research, MIT and IBM working in a joint laboratory etc.

The firms are having their own agendas when it comes to research, as discussed above. Perkmann et al (2013) argue whether collaboration of professors with the industry could lead to an alteration of their agenda towards more applied research to the disadvantage of basic research. Thus, the universities need to make sure that they will be able through these collaborations to maintain to a certain degree their independence in deciding what projects they will pursue. Furthermore, the universities could through the various research agreements that they sign with the companies, request that a percentage of the research will be spent either in basic research or to addressing social problems. In either case, it is a win-win situation for both parties since the university will be able to fund its research and the firms would benefit from increasing their popularity and building a good reputation by making public their societal concerns. Besides, the US government in its report[216] emphasizes the importance of supporting investments in high risk/reward fundamental research with long term horizon. This could be used as an extra leverage for universities to pursue basic research.

Retraining people

The "100 year study on AI" report discusses the disruptive effect of AI technologies in the workplace. As the array of tasks performed by AI expands, more and more people will have to be retrained in order to be able to make a living. The CB insights report[217] emphasize that AI will lead to drastic changes in the labor market. Fields that are affected include among others legal work and programming of pc. Trajtenberg (2018) stresses AI's potential of replacing a large proportion of current forms of employment. McKinsey consulting company performed research[218] on how AI could affect employment. The company estimated that up to 33% of the US workforce might need to change occupation by 2030 due to AI technology. Automation will create challenges.

People of various occupations and ages will have to be retrained within the next decade.

[215] Elizabeth Gibney (2016), AI Talent grab sparks excitement and concern, nature news, springer news, vol 532
[216] NSTC, Networking and Information Technology Research and Development Subcommittee (2016), The national artificial intelligence research and development plan, Office of Science and Technology Policy", page 15
[217] CB insights State of Artificial Intelligence 2018, page 15 and 11
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According to the McKinsey report companies like Walmart and AT&T guide their employees to get university education and to be retrained by paying their tuition fees and related expenses. Other companies like Google create internal academies to train their employees in AI.

In any case this is an opportunity for the university to promote its teaching role and collaborate both with the industry as well as the government so as to facilitate the retraining of the employees.

The university would benefit from acting proactively and commencing the retraining of people so as to be able to adjust more smoothly to the new job skills required. In collaboration with specific firms, the universities could be able to offer customized training to the corporate employees.

8.6 Creating independent thinkers

The most important contribution of the university is to create independent thinkers. The university is an institution that (along with the earlier education system) teaches people how to think. Its purpose is not to provide students with plain theories or a single specialization. The purpose of the university consists in teaching students to think for themselves and offering them tools and directions so as to know when to find the knowledge they need when they need it. It teaches them to choose their sources of information and how to evaluate them.

The university could also contribute by instilling to its students curiosity and interest about society and the world and by helping them become active citizens. Well informed citizens can participate in social debates. Well informed citizens can choose between multiple stimuli, grasp new developments and debate regarding the potential pros and cons of technology instead of being influenced by lateral and directed news and/or fake news.

Conclusion

The university has an eminent role in the Triple Helix model, which in very important in the AI field. The following table summarizes the actions that the university could undertake.

Role of the university	
Ethics & Human rights courses to scientists	Increase diversity in AI staff
AI courses to Law students	Continue basic research
AI courses to all students	Continue addressing social issues
AI related lections and activities for the public	Engage industry into social issues
Retrain people	Retain independence in choice of research field
Educate, keep the politicians/policy makers close and interact often with them	Create independent thinkers & responsible citizens
Press for establishment of standards	Form multi-faculty committees - ignite discussion on AI issues
Make use of double employed professors	Share resources with industry when collaborating

Table 9

The university could utilize all its three missions to create responsible scientists and considerate citizens. AI technologies are in a turning point that require the participation of all stakeholders so as to maximize the benefits and minimize the possible shortcomings. The previous chapters have debated that the industry and the government have different criteria in evaluating AI, which don't always include social responsibility. The university could act as the link that will pressure the other two helixes towards a more transparent and regulated state in the field.

9 Conclusion

This last chapter is dedicated to the conclusion of the thesis, which involved the study of the AI system in the USA. The term AI was explained and thorough examples of its applications were provided. The disruptive effects of AI technologies in the economy and the society were presented and the possible risks were portrayed. The examples that were dispersed throughout this thesis served as an illustrator of the significance of the field.

The thesis started with the question about the state of the AI field in the USA, as it is the leading country in the AI race at the time. The recent publication of various scandals regarding the misuse of algorithms, mostly in the USA but internationally as well, and their impact on society called for a framework which would explain the dynamics of the AI system and would illuminate the causes of these malfunctions. The Triple Helix model of innovation was selected to chart and comprehend the dynamics and the network of relations between the three institutional spheres: the government, the university and the industry. BIG DATA are an important part of the AI system that need to be taken into consideration, since biases in data that go undetected are augmented when incorporated in algorithms. The TH allowed for the citation of the history of the sector from its beginnings in the 1950's up to today and portrayed the reasons that have led to the current state of the sector. The TH model provided a framework that could serve as a base for the discussion of probable opportunities and/or risks regarding AI technologies.

The TH model demonstrated the domination of a few big tech companies in the AI field and revealed the phenomenon of the privatization of research with the following main characteristics/attributes in the system: the industry leads the research and is the main financier, there is a high concentration with few big corporations that expand through mergers and acquisitions, these few companies have the control of vast amounts of data that are required for the training of AI, the state is unable/unwilling to regulate the field for a number of reasons and last both the industry and the government value the contribution of the entrepreneurial university and work close together. The privatization of the research as discussed in chapter 7 appears to have long term effects on the innovation and the growth of the society and the economy.

The AI field is in its first steps, as far as the development and use of widely used applications is concerned, and the changes are rapid. Many AI applications are circulated first and the drawbacks are revealed at a later time and are patched by the companies. There is a

considerable general lack of regulation in the field as with all new technologies. AI poses considerable legal, ethical and social challenges that have not been addressed yet not only in the USA but globally. The incorporation of ethics in AI and the systematic avoidance of biases are yet to be resolved. In addition, often researchers cannot explain how various AI systems reached their conclusions.

For all the reasons mentioned in the previous chapters it is of great significance that the university takes decisive steps to enhance its role by emphasizing all three missions. The proposals of the eighth chapter set the directions for the university to become more active in this fluid and rapid changing field. The teaching mission of the university is crucial for the students and later future scientists, employees and entrepreneurs to be trained in AI related issues and always incorporate ethics in their field of work. The research mission of the university is vital to continue to invest in basic research and address societal issues. The third mission of the university is important, among others, to interact with and train the society for the forthcoming changes, liaise with the government and the industry to set standards, inform and confer with the policymakers for possible legal implications, set up multi-disciplined committees for the discussion and resolution of AI issues etc.

The AI technologies are very promising and could potentially address many social issues and improve greatly the lives of people. However, the risks of their misuse are also high. The collaboration of all stakeholders is required. The civil society, the scientists, the government, the industry, academics all need to be informed and to participate in the discussions.

The AI field is vast and its disruptive impact on society and economy raises questions for many faculties such as lawyers, economists, sociologists, engineers, hr managers etc. Further research is needed on the effects of AI in the workforce as well as in the establishment of legislation that will address the countless ethical questions on responsibility, transparency and accountability of AI.

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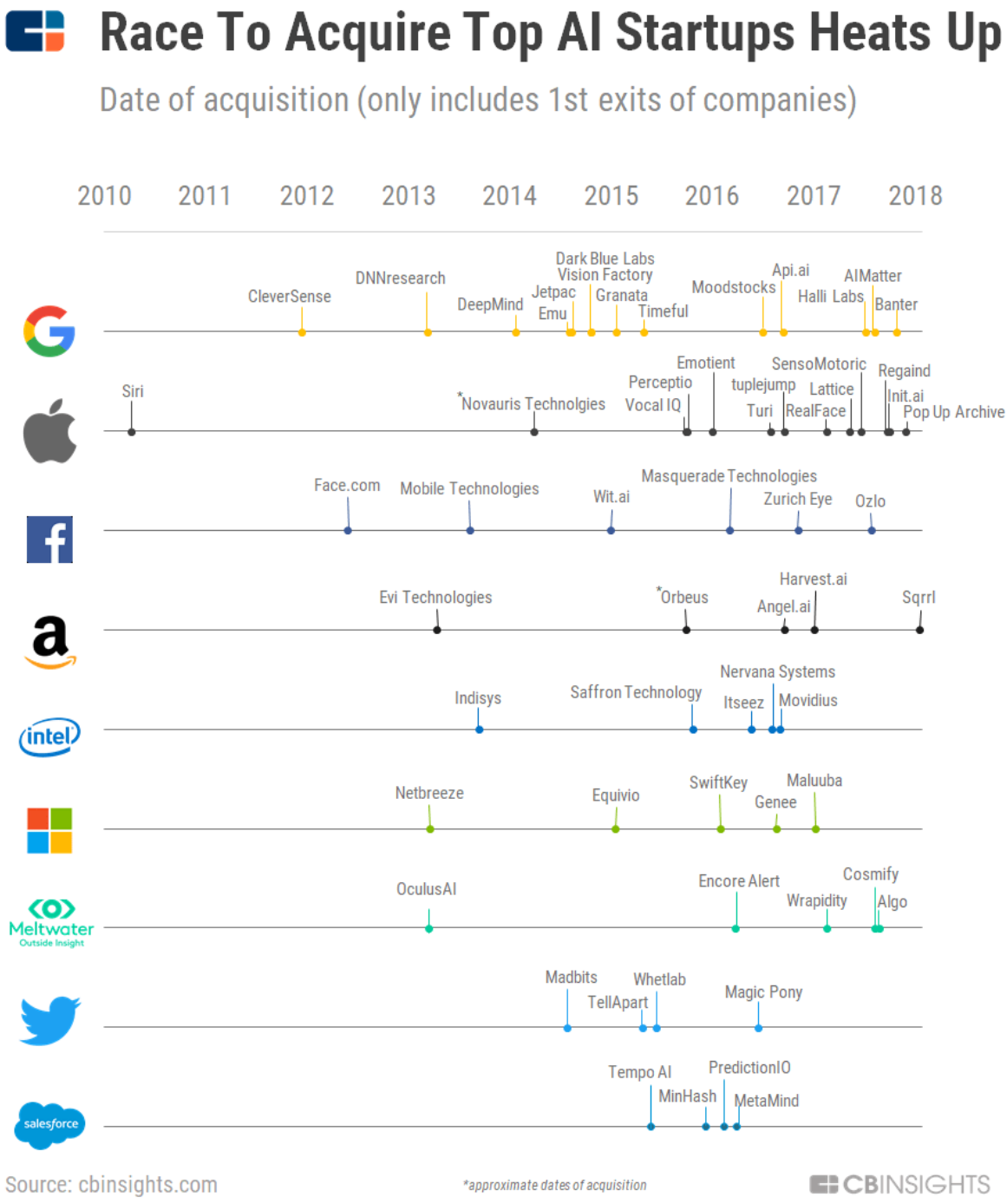
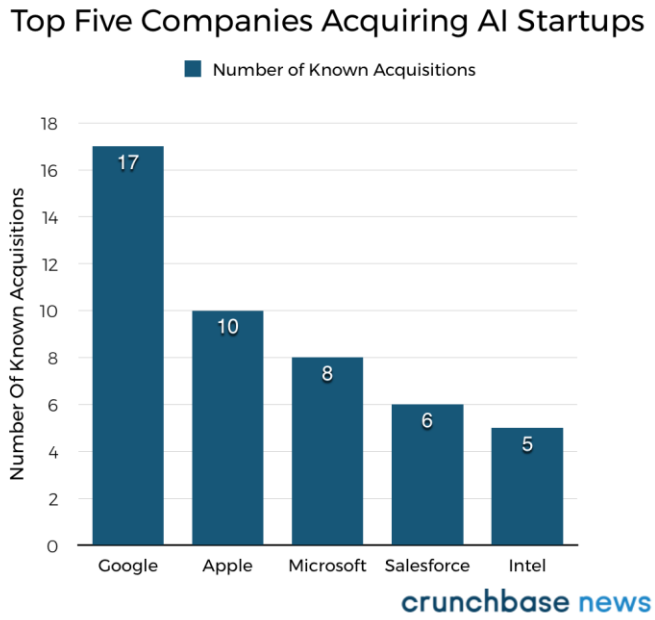
Appendix A



Source: The Race For AI: Google, Intel, Apple In A Rush To Grab Artificial Intelligence Startups (27/2/2018. https://www.cbinsights.com/research/top-acquirers-ai-startups-ma-timeline/ accessed 24/4/2018

The graph depicts the mergers and acquisitions of big companies (if the number of M&A>4) since 2010.

Crunchbase offers a different picture of the acquisitions, since the period extends form 2007-2017



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Appendix B

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This is the table 3 from the abovementioned article and is presented here in order to emphasize the amount of data, sensitive and no sensitive, that people give away today.

Table 3. Ontological traits of Big Data.

Data type		Volume (number of records)	Volume per record	Volume (TBs, PBs, etc.)	Velocity frequency of generation	Velocity frequency of handling, recording, publishing	Variety	Exhaustivity	Resolution	Indexical	Relational	Extensionality	Scalable
Mobile communication	Mobile phone data	High	Low	High	Real-time constant (bkgrd comms), real-time sporadic (at use)	At time of generation	Structured	$n = all$	Fine-grained	Yes	Yes	No	Yes
	App data	High	Low	High	Real-time constant (bkgrd comms), real-time sporadic (at use)	At time of generation	Structured & unstructured	n = all	Fine-grained	Yes	Yes	Yes	Yes
Websites	Web searches	High	Low	High	Real-time sporadic	At time of generation	Structured & unstructured	$n = all$	Fine-grained	Yes	Yes	Yes	Yes
	Scraped websites	High	Medium	High	Real-time sporadic	At time of generation	Semi-structured	$n = all$	Fine-grained	Yes	Yes	Yes	Yes
	Clickstream	High	Low	High	Real-time sporadic	At time of generation	Structured	$n = all$	Fine-grained	Yes	Yes	Yes	Yes
Social media/ Crowdsourcing	Social media (full pipe) (e.g. Twitter)	High	Medium	High	Real-time sporadic	At time of generation	Structured & unstructured	$n = all$	Fine-grained	Yes	Yes	Yes	Yes
	Social media (spritzer) (e.g. twitter)	Low	Medium	Medium	Real-time sporadic	At time of generation	Structured & unstructured	Sampled	Fine-grained	Yes	Yes	Yes	Yes
	Picture sharing/ social media (flickr, Panoramio, Instagram)	High	High	High	Real-time sporadic	At time of generation	Structured & unstructured	$n = all$	Fine-grained	Yes	Yes	Yes	Yes
	Collaborative mapping platforms (OpenStreetMap, Wikimapia)	Low	Low	Low	Real-time sporadic	At time of generation (open to editing)	Structured & semi-structured	$n = all$	Fine-grained	Yes	Yes	Yes	Yes
	Citizen science (wunderground)	High	Low	Medium	Real-time constant or real-time sporadic	At time of generation	Structured	$n = all$	Fine-grained	Yes	Yes	No	Yes
Sensors	Traffic loops	Medium	Low	Low	Real-time constant	At time of generation	Structured	$n = all$	Aggregated	Yes	Yes	No	No

(continued)

Table 3. Continued

Data type		Volume (number of records)	Volume per record	Volume (TBs, PBs, etc.)	Velocity frequency of generation	Velocity frequency of handling, recording, publishing	Variety	Exhaustivity	Resolution	Indexical	Relational	Extensionality	Scalable
	Automatic Number Plate Readers (ANPR)	Medium	Low	Medium	Real-time constant	At time of generation	Structured	$n = all$	Fine-grained	Yes	Yes	No	Yes
	Real-time passenger info (RTPI)	Medium	Low	Low	Real-time constant	At time of generation	Structured	$n = all$	Fine-grained	Yes	Yes	No	No
	Smart meters	High	Low	Medium	Real-time constant	At time of generation	Structured	$n = all$	Fine-grained	Yes	Yes	No	No
	Pollution and sound sensors	Medium	Low	Low	Real-time constant	At time of generation	Structured	$n = all$	Fine-grained	Yes	Yes	No	No
	Satellite images	Medium	High	High	Real-time constant	At time of generation	Unstructured	$n = all$, delayed repeat of coverage	Fine-grained	Yes	Yes	No	No
Cameras/Lasers	Digital CCTV	High	High	High	Real-time constant	At time of generation	Unstructured	$n = all$	Fine-grained	Yes	Yes	No	No
	Lidar mapping (by HERE)	High	High	High	Real-time constant (when in use)	Delayed and consolidated (daily)	Structured	$n = all$, but no or infrequent repeat coverage	Fine-grained	Yes	Yes	No	No
Transactions of process generated data	Supermarket scanner and sales data	High	Low	High	Real-time sporadic	At time of generation	Structured	$n = all$	Fine-grained	Yes	Yes	No	Yes
	Immigration (inc. photo, fingerprint scan)	Low	High	High	Real-time sporadic	At time of generation	Structured	$n = all$, infrequent repeat coverage	Fine-grained	Yes	Yes	No	Yes
	Flight movements	High	Low	High	Real-time constant	At time of generation	Structured	$n = all$	Fine-grained	Yes	Yes	No	Yes
	Credit card data	High	Low	High	Real-time sporadic	At time of generation	Structured	$n = all$	Fine-grained	Yes	Yes	No	Yes
	Stock market trades	High	Low	High	Real-time sporadic	At time of generation	Structured	$n = all$	Fine-grained	Yes	Yes	No	Yes
Administrative	House price register	Low	Low	Low	Real-time sporadic	Delayed and consolidated (monthly)	Structured	$n = all$	Fine-grained	Yes	Yes	No	Yes

(continued)

Table 3. Continued

Data type		Volume (number of records)	Volume per record	Volume (TBs, PBs, etc.)	Velocity frequency of generation	Velocity frequency of handling, recording, publishing	Variety	Exhaustivity	Resolution	Indexical	Relational	Extensionality	Scalable
	Planning permissions	Low	Low	Low	Real-time sporadic	Delayed and consolidated (weekly)	Structured	n = all, but no or infrequent repeat coverage	Fine-grained	Yes	Yes	No	Yes
	Employment register (at release)	Low	Low	Low	Real-time sporadic	Delayed and consolidated (monthly)	Structured	n = all	Aggregated	Yes	Yes	No	Yes

bkgrd comms: constant background passive monitoring.