Introduction

The role of Artificial Intelligence (AI) in business and the global economy is a hot topic. AI is the subject of countless discussions and articles. An investigation into the popularity of AI on the internet, news, and business from 2008 to 2017 via Google Trends and CB Insights[1] show from 2016, there has been a drastic increase in the number of mentions of the word "artificial intelligence". The results are illustrated in Figure 1.

Many people have a different interpretation and understanding of AI. Therefore, it is a good place to first understand, what is Artificial Intelligence?

What is Artificial Intelligence?

Artificial intelligence (AI) is a wide-ranging branch of computer science concerned with building smart machines capable of performing tasks that typically require human intelligence[2].

The oxford dictionary defines Artificial Intelligence as:

"*The theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages.*"

Academics have defined AI as:

"The study of how to make computers do things at which, at the moment, people are better."[3]

The UK government has defined AI as:

"*Technologies with the ability to perform tasks that would otherwise require human intelligence, such as visual perception, speech recognition, and language translation."*[4]

From all these different interpretations of AI, we can conclude that AI is not a single technology but a family of technologies.

Sub-fields of Artificial Intelligence

Artificial Intelligence is predominantly divided into two categories:

1. Narrow AI
2. General AI

Narrow AI is concerned with performance in a specific task such as email spam filtering or product recommendation. In contrast, General AI is focused on machines that can apply their intelligence to any task. General AI is viewed among academics as the pinnacle and significant advancement has been made in this area. For example, in 2017 Google DeepMind introduce AlphaZero, a computer program that was able to learn to play chess in 24 hours and was able to defeat the world champion programs Stockfish and elmo[5].

For this paper, I aim to focus on narrow AI because it the group of AI that is mainly used in business. Narrow AI itself is still a broad field, I categories Narrow AI in the following group:

1. Evolutionary Computations
2. Vision
3. Robotics
4. Expert Systems
5. Speech Processing
6. Natural Language Processing
7. Machine Learning

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[1] The Age of Analytics: Competing in a Data-Driven World Notes

[2] https://builtin.com/artificial-intelligence

[3] E. Rich and K. Knight. Artificial intelligence. McGraw-Hill, New York, NY, 2nd edition, 2009 and E. Rich, K. Knight, and S. B. Nair. Artificial intelligence. Tata McGraw-Hill, New Delhi, 3rd edition, 2009.

[4] Industry Strategy: building a Britain fit for the future, 2017

[5] A general reinforcement learning algorithm that master's chess, shogi, and Go through self-play by David Silver et al

Given this broad field, I aim to focus on Machine Learning, and it is defined as a set of methods that can automatically detect patterns in data, and then use the uncovered patterns to predict future data, or to perform other kinds of decision making under uncertainty[6]. Moving forward in this paper, when I refer to Artificial Intelligence (AI) I mean Machine Learning.

The resurgence of AI in research, funding, and conversation is due to development in three areas:

1. **Power and Capacity**: The power and speed at which modern computers can currently operate are much stronger and faster than in the past. Advancements have been from CPU[7] to GPU. Today's GPU can be 40 to 80 times fasters than the quickest versions in 2013. Also, cloud storage offers much cheaper computing and storage services than was previously available.
2. **Data**: The increased use of the internet and smart technology has led to an explosion of data collected daily. The International Data Corporation estimates that there may be 163 zettabytes of data by 2025, which is 10 times the data generated in 2016[8]. The vast amount of data means new insights can be found that were previously unavailable in the past.
3. **Advancement in Research**: In AI, the development of deep learning techniques such as neural networks has improved the accuracy of classification and prediction problems[9]. Reinforcement learning, a method that allows programs to learn by trial and error and improve their performance through repetition has also helped[10].

The progress made in these three areas has put the spotlight back on AI.

Outlook of AI

The AI is a unique phenomenon, in the sense that it is not an outright new sector but rather a tool that will be used in established sectors for growth and competitive advantage. When deciding to utilise this technology, companies have two options. Develop the capabilities internally or acquire/partner with an external firm. The latter is the approach adopted by a majority of firms, even the technology giants of Amazon and Google. Google has borne the brunt of many jokes as of recent, given the fact that it is the only technology company that has a mergers and acquisitions department.

Figure 4 shows the number of acquisitions of AI companies from the top 5 technology companies from 2010-2019.

I can say that a majority of companies utilising AI are start-ups in established sectors. Research by academics at the University of Delhi looked at the top 100 AI-based start-ups globally in 2017 and 2018 to analyse the distribution in terms of industry, funding, and geography.

Figures 5a and 5b illustrate the percentage of companies in their respective industries for 2017 and 2018. In 2017, sectors such as healthcare and business intelligence had a large concentration of start-ups which shifts in 2018 to cybersecurity. The industries that were common in both years were healthcare, cybersecurity, business intelligence, marketing & sales, autonomous vehicles, financial services, Internet of Things, and robotics.

Figures 6a and 6b show the geographic distribution of the start-ups in 2017 and 2018. The results found are as expected. Given there are 195 countries in the world, all the start-ups for both years are located in just 13. The majority of start-ups are in American, with their headquarters in California.

The Current State of AI in Business

AI has witnessed a vast amount of investment in the past few years. McKinsey & Company estimated between $20-$30 billion in 2016. The majority of this investment is from Mergers & Acquisition activity, Venture Capital account for $4-$5 billion and Private Equity $1-$3 billion[11].

This increase in investment and advancement in technology all leads to one question. What effect is AI having on businesses?

Insights from Business Use Case

McKinsey Global Institute researched the uses of AI in business by mapping various AI techniques to problems they can solve using more than 400 use cases in businesses across 19 industries and 9 business functions. Names of specific companies are not included due to client confidentiality agreements. The AI techniques, McKinsey focus on are traditional and newer analytical techniques.

The analytical techniques examined for the research are:

1. Transfer Learning*

[6] Machine Learning A Probabilistic Perspective by Kevin P. Murphy
[7] CPU are Computer Processing Units and GPU are Graphic Processing Units
[8] John Gantz, David Reinsel, and John Rydning, *Data age 2025: The evolution of data to life-critical*, IDC white paper, April 2017
[9] Yoshua Bengio, Aaron Courville, and Ian Goodfellow, *Deep Learning*, Cambridge, MA: MIT Press, 2016.
[10] Matt Burgess, "DeepMind's latest AI breakthrough is its most significant yet," *Wired*, October 18, 2017
[11] Artificial Intelligence: The Next Digital Frontier? By McKinsey Analytics

2. Reinforcement Learning*
3. Deep Learning Neural Network*
4. Dimensionality Reduction
5. Ensemble Learning
6. Regression Analysis
7. Decision Tree Learning
8. Monte Carlo Methods
9. Linear Classifiers
10. Clustering
11. Statistical Inference
12. Markov Process
13. Regression Analysis
14. Descriptive Statistics
15. Naïve Bayes Classifier

* indicates Advance AI techniques

The analytical techniques fit into the definition of AI that I use in this study. McKinsey was able to find real-life problems solved by one or a combination of these techniques. The type of problems discovered was:

1. **Classification:** Categorise inputs as belonging to one of a set of categories. An example of classification is whether an image contains a specific type of objects such as a truck or a car.
2. **Prediction**: Estimating the next value in a sequence. An example is forecasting the sales demand for a product or predicting the price of real estate such as a building.
3. **Clustering**: Individual data points that have a set of common or similar characteristics are group together. An example is creating a set of consumer segments based on data about individuals.
4. **Optimisation**: A system generates a set of outputs that optimise outcomes for a specific objective function. An example of optimisation is generating a route for a vehicle that creates an optimum combination of time and fuel.
5. **Anomaly detection**: Determine whether specific inputs are out of the ordinary. An example is fraud detection. This can also be seen as a form of classification.
6. **Ranking**: The results of a request needs to be ordered by some criterion. An example is product recommendation.
7. **Data generation**: A system to generate appropriately novel data based on past data. An example music composition system will be used to generate a new piece of music in a particular style.

Figures 2 and 3 are heatmaps that show the extent to which applicable techniques can be used by industry and function based on the McKinsey & Company's library of use cases[12].

Traditional analytical techniques such as Regression, Linear Classifiers, and other forms of statistical inference are shown to have the widest scope of applicability across industries and functions.

More advance AI analytical techniques such as deep learning and reinforcement learning have shown potential, but their usage is not yet widespread. At present, these methods are found to be most useful in Insurance, Banking, Automotive and Assembly, and Retail for business sectors. While for functions they are most useful in marketing and sales and supply chain management and manufacturing.

Figures 2 and 3 provide valuable insight into the current states of AI in business. I know that advanced AI techniques have been proven to produce more accurate results, yet businesses prefer to use traditional approaches.

The McKinsey report states that 69% of all the use case studies in their report could be improved through the use of advanced AI techniques. 16% of studies use cases current employ only advanced AI technique. Illustrating the great potential that these advanced AI techniques have to help business.

Growth from AI

From the 400 business cases, McKinsey & Company have estimated that the advanced AI techniques have the potential to create between $3.5-$5.8 trillion in value annually across all 9 business functions in 19 industries. This estimation was obtained using the value created in the use cases and the potential value in projected future ones. This value is not a forecast over a period of time but rather represents the potential this advance AI techniques can add to the global economy. This percentage of this potential that can be achieved by different businesses and sectors will be dependent on competition, market dynamics, policymakers, and Individual business decisions.

Limitations and Concerns of AI in Business

[12] A use case is defined as a targeted application of analytical techniques to a business challenge with a measurable outcome.

The previous section has highlighted an interesting situation, in which businesses are not using advanced AI techniques given these techniques have been proven to outperform traditional AI techniques. Therefore, for all the promise, AI has plenty of limitations that will need to be overcome to fully harness their full potential. Among the limitation 6 stand out:

1. **Talent**: Individuals within an organisation who can use, understand, and explain AI are essential for businesses to adopt more advanced AI techniques. A McKinsey & Company survey found approximately half of the executives across geographies and industries reported greater difficulty recruiting analytical talent than filling any other kind of role[13].

2. **Explainable AI**: This is a growing sub-field of AI, which is concerned with understanding and explaining how inputs alter outputs. More advanced AI techniques such as neural networks tend to have complex mechanisms than traditional AI techniques such as linear regression. The inability to explain the models in sectors where transparency of decision making may be needed for regulatory purposes may scare management away.

3. **Bias**: AI models learn tasks from data. Bias in data through the method of collection or in the current state of society can create datasets that influence the behaviour of AI. AI that has pre-existing social and cultural bias could negatively impact an organisation from a legal and moral standpoint.

4. **Data**: Advance AI techniques require large, labelled datasets to train the models, which also required constant updating daily or weekly. Businesses may not have the infrastructure to collect and store data. Firms may not also have the time to clean and format the data correctly to be used for training AI.

5. **Generalisation of Learning**: AI models still have difficulty carrying their experiences from task to another, which leaves firms having to commit resources to train new AI even if tasks are relatively similar to previous ones.

6. **Regulation**: The use and storage of personal information are especially sensitive in some sectors. For example, in the EU, automated individual decision making is shaped by general data protection regulation which provides a right to an explanation for some decisions made by machines.

Case Studies

Otto[14]

Otto is a German mail-order company and one of the world's largest e-commerce companies. It is based in Hamburg and operates in more than 20 countries.

Otto noticed that the returns of products were losing the company millions of euros a year. It decided to use AI to improve this activity. Conventional data analysis showed that customers were more likely to return items if they arrived more than 2 days after purchase and large orders arrived in separate deliveries.

Otto decided to partner with Blue Yonder, to design a deep learning algorithm that was able to analyse around a billion past transactions and 200 variables such as past sales, customer search results, and weather information to predict what customers will buy a week before they order.

The AI system has proved to be extremely reliable with an accuracy of 90%. Otto allows the AI system to automatically purchase around 200,000 items a month from third-party brands with no human intervention.

Overall, the surplus stock has declined by a fifth and returns have reduced by more than 2 million items a year.

Amazon[15]

Amazon is an American multination technology company based in Seattle. The company has operations in e-commerce, cloud computing, digital streaming, and artificial intelligence. It is considered as one of the big four technology companies in the world.

In 2012, Amazon purchased Kiva, a start-up robotics company for $775 million. In 2014, Amazon started using the robots made by Kiva to automate the picking and packing process at their large warehouses.

[13] The Age of Analytics: Competing in a Data-Driven World
[14] "How Germany's Otto uses artificial intelligence" – The Economist, April 12, 2017
[15] "Amazon's $775 million deal for robotics company Kiva is starting to look really smart" – Business Insider, June 15, 2016

From 2014 to 2016, Kiva's robots have been deployed in 12 out 110 fulfilment centres and has shown tremendous potential to be a real cost saver. During that period, the Kiva robots have cut operating expenses by 20% according to Amazon's Senior Vice President of Worldwide Operations Dave Clark. He adds that this would translate to $22 million in cost-saving for each fulfilment centre.

Extending Mr. Clark logic, this would amount to savings over $2 billion across all 110 fulfilment centres. Netting Amazon a cool $1.2 billion gain by purchasing Kiva. Deutsche Bank took a conservative approach to estimate potential saving for Amazon and found only $800 million in a one-time cost saving could be made if Kiva was deployed to all 110 fulfilment centres.

Stitch Fix[16]

Stitch Fix is an online personal styling service in the United States. The company was founded in 2011 and had an initial public offering in 2017 with a valuation of $1.6 billion. Stitch Fix has a customer base of 3 million, headquarters in San Francisco, California, and employs 8,000 people worldwide.

Stitch Fix follows a simple business model It uses recommendation algorithms and data science to personalise clothing items based on size, budget, and style. Items are sent out to customers; customers purchase the items they want and return the items they do not want.

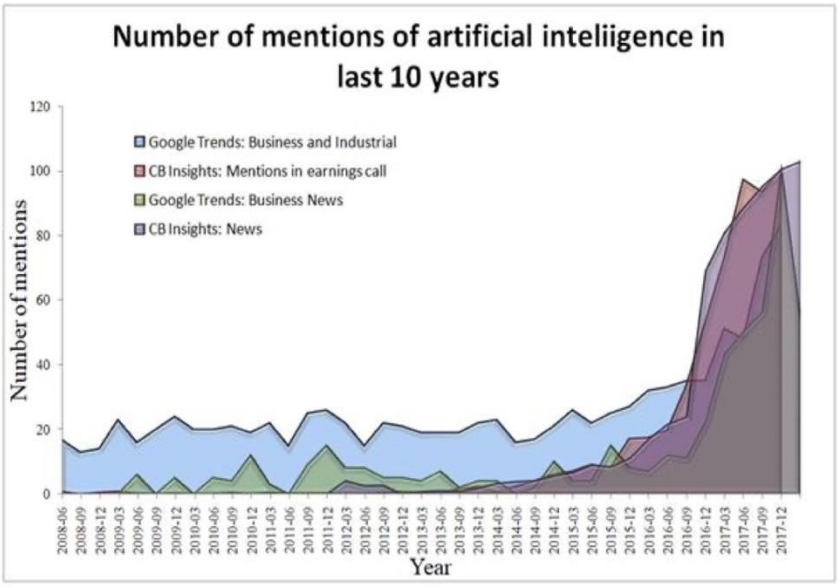
Stitch Fix has seen sales continue to grow. In 2016, sales were $730 million, in 2017, sales were $977 million and in 2018 sales were over $1 billion. 100% of revenue generated results directly from recommendation by algorithms, which is the core of Stitch Fix business.

Conclusion

In this study, I have been able to present several definitions of AI. I have shown that the resurgence in AI is down to advancements made in computing, data, and AI techniques. The outlook of AI shows that a majority of firms operating in this space are start-ups. They mainly engage in the healthcare and high technology sectors. In terms of geographical location places a large number in America and the rest scattered between Canada, Western Europe, and India. The current state of AI in business is traditional AI techniques such as regression and decision trees that are well established and widely used across business sectors and functions. Whereas, more advanced AI techniques such as deep and reinforcement learning is rarely used across business sectors and functions. This is a key find in this paper, as it shows that although academic research has shown advanced AI techniques can outperform traditional AI techniques. Businesses are reluctant to adopt these methods. I was able to find six reasons to explain the hesitation of businesses. They were talent, explainability, bias, data requirement, generalisation of learning, and regulation. I believe as an investor, these limitations provide a good starting point to build questions such as how does an organisation store and use data? Does any of an organisation key operation fall into the category of Classification, Prediction/Forecasting, or Optimisation? How is the performance within the organisation currently measured? These types of questions can be used to assess whether or not a company is current AI-ready.

Appendix

Figure 1



SOURCE: Impact of Artificial Intelligence on Businesses: from Research, Innovation, Market Deployment to Future Shifts in Business Models

Figure 2

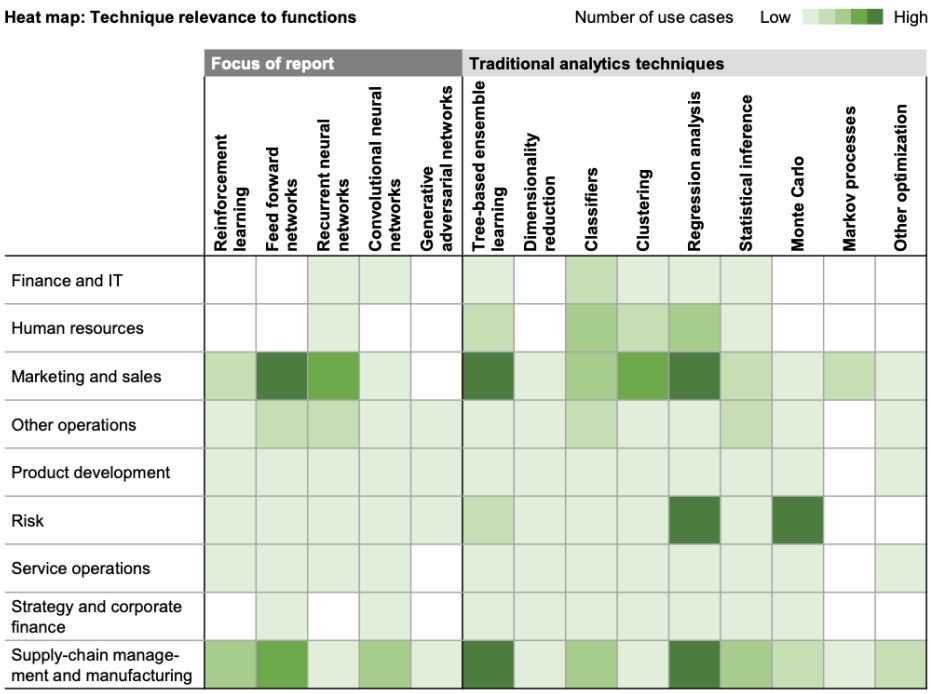
[16] "Stitch Fix's CEO on Selling Personal Style to the Mass Market" – Harvard Business Review, May-June Issue, 2018

Heat map: Technique relevance to industries

Number of use cases Low High

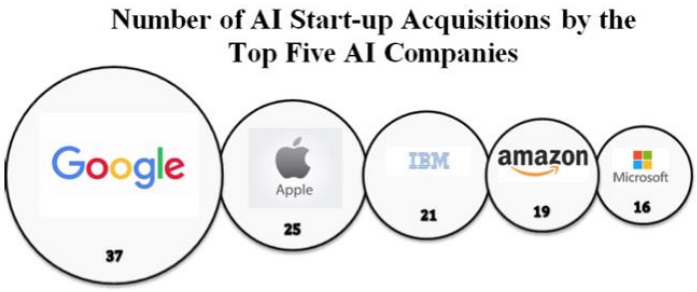
SOURCE: McKinsey Global Institute analysis

Figure 3



SOURCE: McKinsey Global Institute analysis

Figure 4



SOURCE: Impact of Artificial Intelligence on Businesses: from Research, Innovation, Market Deployment to Future Shifts in Business Models

Figure 5a

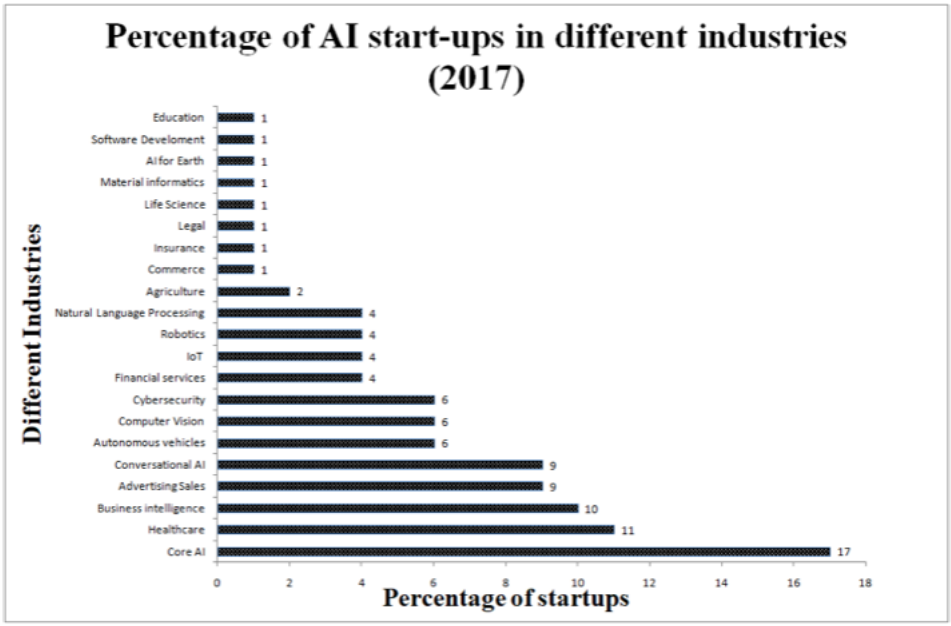
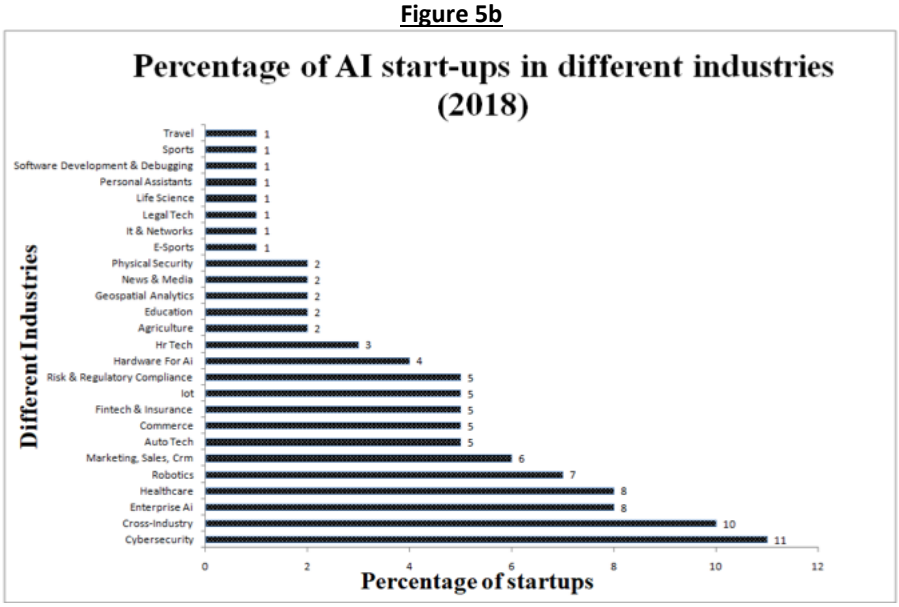


Figure 5b



SOURCE: Impact of Artificial Intelligence on Businesses: from Research, Innovation, Market Deployment to Future Shifts in Business Models

Figure 6a

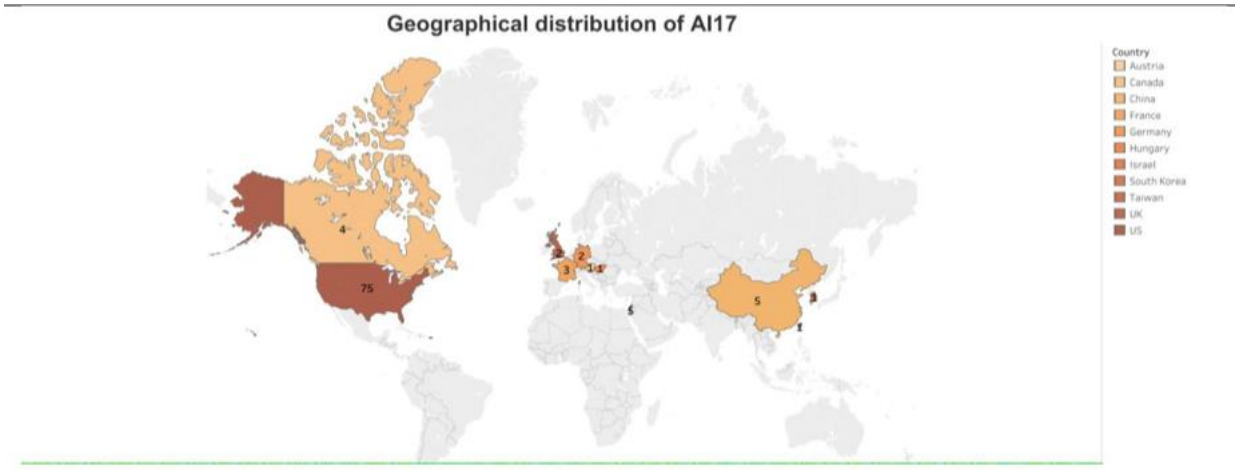
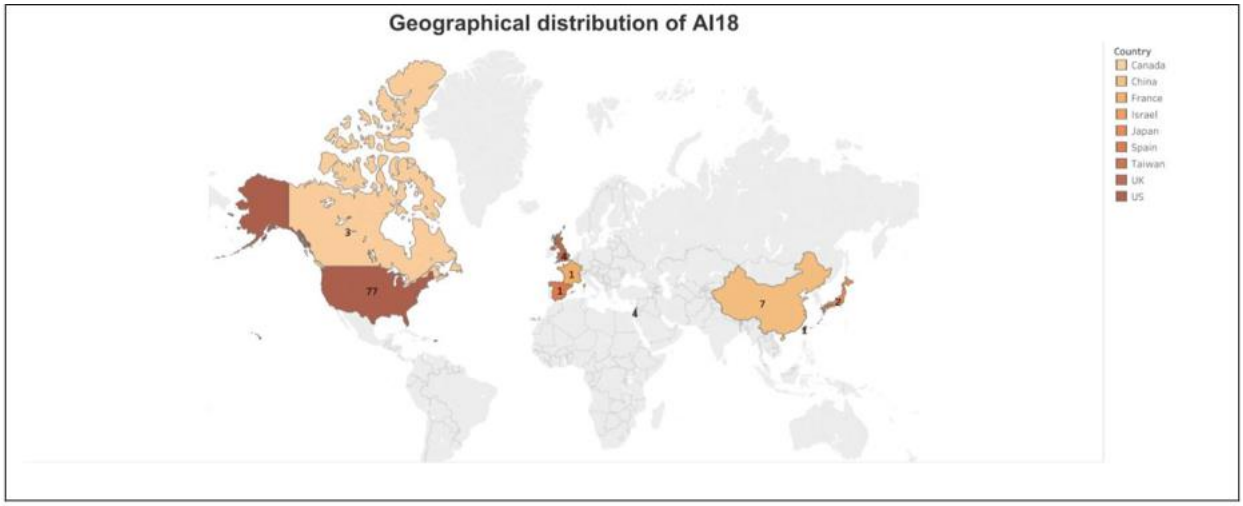


Figure 6b



SOURCE: Impact of Artificial Intelligence on Businesses: from Research, Innovation, Market Deployment to Future Shifts in Business Models