

Week 1/Day 1 Reader for Artificial Intelligence in the Economy, 2022

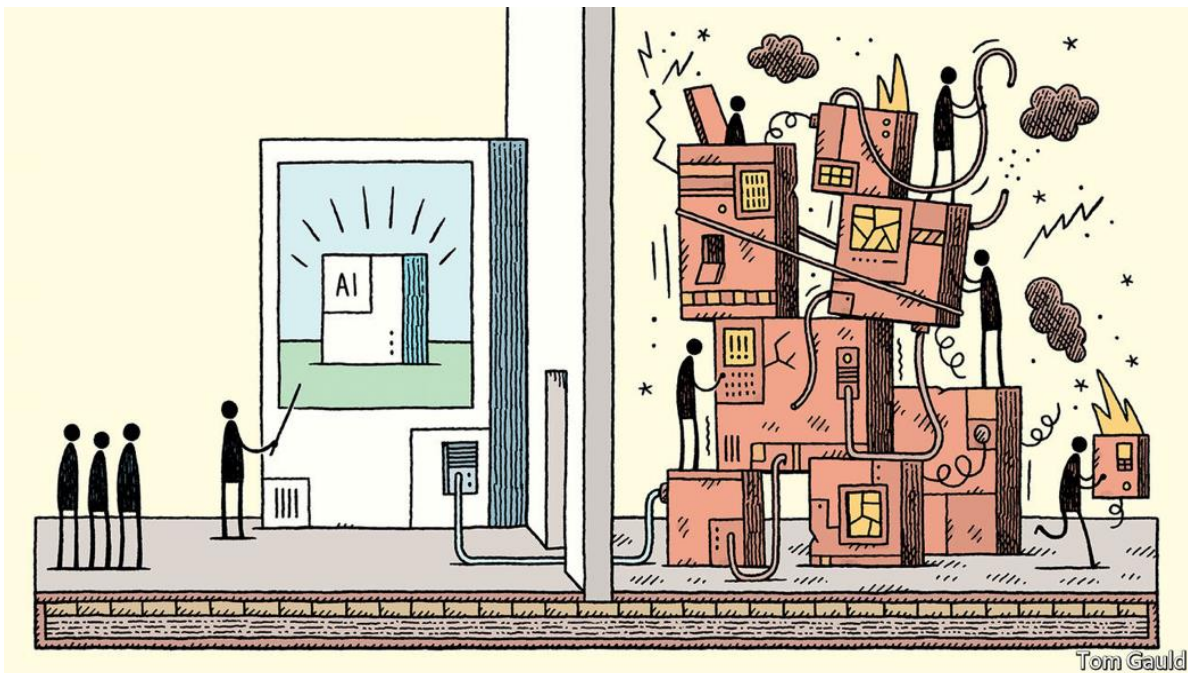
Some AI Humor

When I was a child I saw "2001: A Space Odyssey" and then read everything I could about A.I. All the smart people said it was 20 years away. Twenty years later I was an adult and the smart people said that A.I. was 20 years away. Twenty years after that we passed 2001 and the smart people said it was about 20 years away... Now is the time to listen to smarter people.

Penn Jillette

Below are two cartoons. *What do they mean, why have I chosen them and what are their key messages?*

Cartoon 1



Cartoon 2



(R. Kikuo Johnson / The New Yorker)

Preliminaries

Get familiar with the phrases Artificial Intelligence, Data Science and Machine Learning via the following resources (or many, many others):

- https://en.wikipedia.org/wiki/Artificial_intelligence
- https://en.wikipedia.org/wiki/Data_science
- https://en.wikipedia.org/wiki/Machine_learning
- Youtubes on each
 - <https://www.youtube.com/watch?v=61RbzGBpBIs>
 - <https://www.youtube.com/watch?v=O76A0FIFdqs>
 - <https://www.youtube.com/watch?v=HcqpanDadyQ>
<https://www.youtube.com/watch?v=nKW8Ndu7Mjw>
<https://www.youtube.com/watch?v=aircAruvnKk>

What is AI Anyway? - Defining AI

What does the phrase “AI” actually mean? Here are some definitions: (by the way, *why are definitions important? Are robots AIs?*)

<https://www.youtube.com/watch?v=HX6M4QunVmA&t=220s>

1. the theory and development of computer systems able to perform tasks that normally require human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages
2. making self-improving machines that use language, form abstractions and solve problems previously reserved for humans
3. the study of “intelligent agents” - any device that perceives its environment and takes actions that maximize its chance of successfully achieving its goals

What do these definitions have in common?

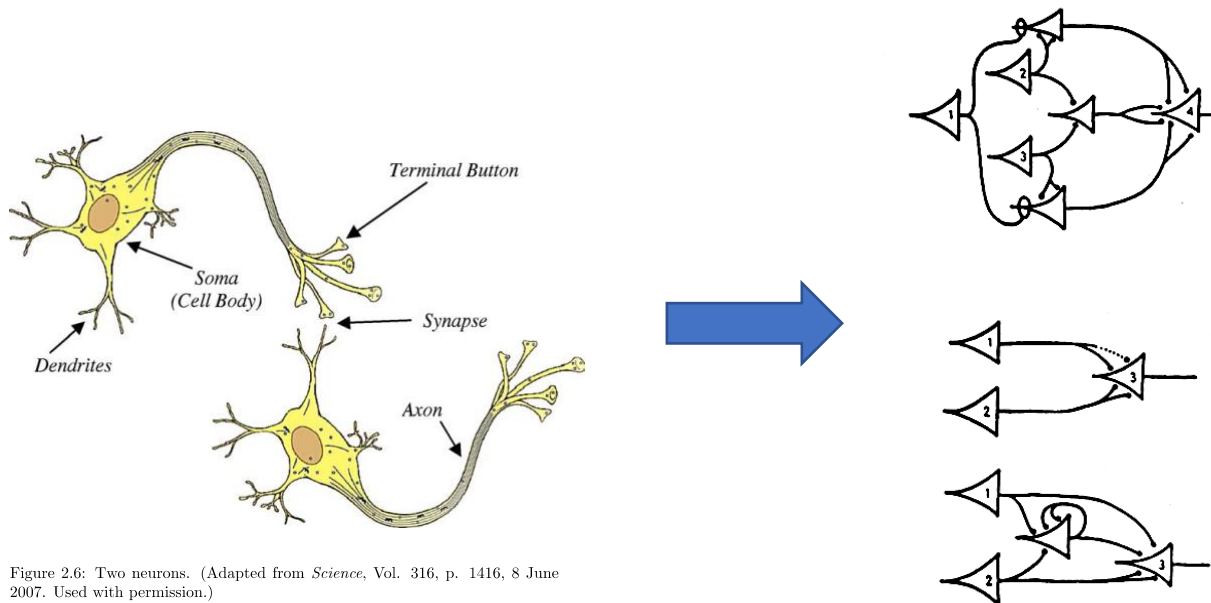
The History of AI

An excellent and comprehensive treatise on the history of AI (caveat – it was published in 2010) can be found in the document *The Quest for Artificial Intelligence – A History of Ideas and Achievements* by Nils Nilsson at https://www.academia.edu/7921844/THE_QUEST_FOR_ARTIFICIAL_INTELLIGENCE

AI has a surprisingly long history (depending on your definitions). An unusual “pre-historic” point that I find interesting is drawings sketched by Leonardo Da Vinci in the mid-1490s of a “humanoid robot”



Fast forward a few hundred years and a line of thinking that the human brain provides both a conceptual as well as a computational model was elucidated in the 1940s by McCulloch and Pitts in their paper *A Logical Calculus of Ideas Immanent in Nervous Activity* <http://www.cse.chalmers.se/~coquand/AUTOMATA/mcp.pdf> This provided a nice precursor for Neural Networks and “Deep Learning” that are so important in AI today



Practical History

The more practical history can be traced backed to three important meetings held in the 1950s:

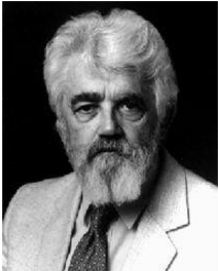

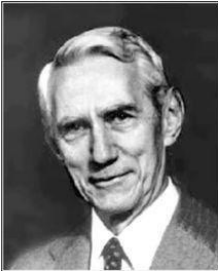
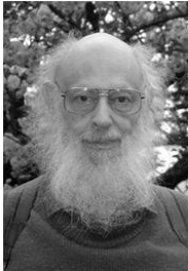



- the 1955 *Session on Learning Machines*
<https://dl.acm.org/doi/10.1145/1455292.1455308> with a paper contributed by Oliver Selfridge which is arguably a key starting point for the field of Machine Vision
- the 1956 *Dartmouth Summer Research Project on Artificial Intelligence*
- <https://ojs.aaai.org//index.php/aimagazine/article/view/1904>

- the 1958 symposium entitled *Mechanization of Thought Processes* in the United Kingdom (I point to this as an early example of the potential globalization of AI even early on)

Of these three, we should highlight the Dartmouth Summer Research Project as the truly seminal event. Read through this paper (the link is above)

- **Questions:** (1) how many people, how much money and what time period was involved? (2) what aspects of AI do they propose to work on? (3) are these aspects still relevant today? (4) what happened to the named people? (5) how much optimism was expressed?

1956 Dartmouth Conference:
The Founding Fathers of AI

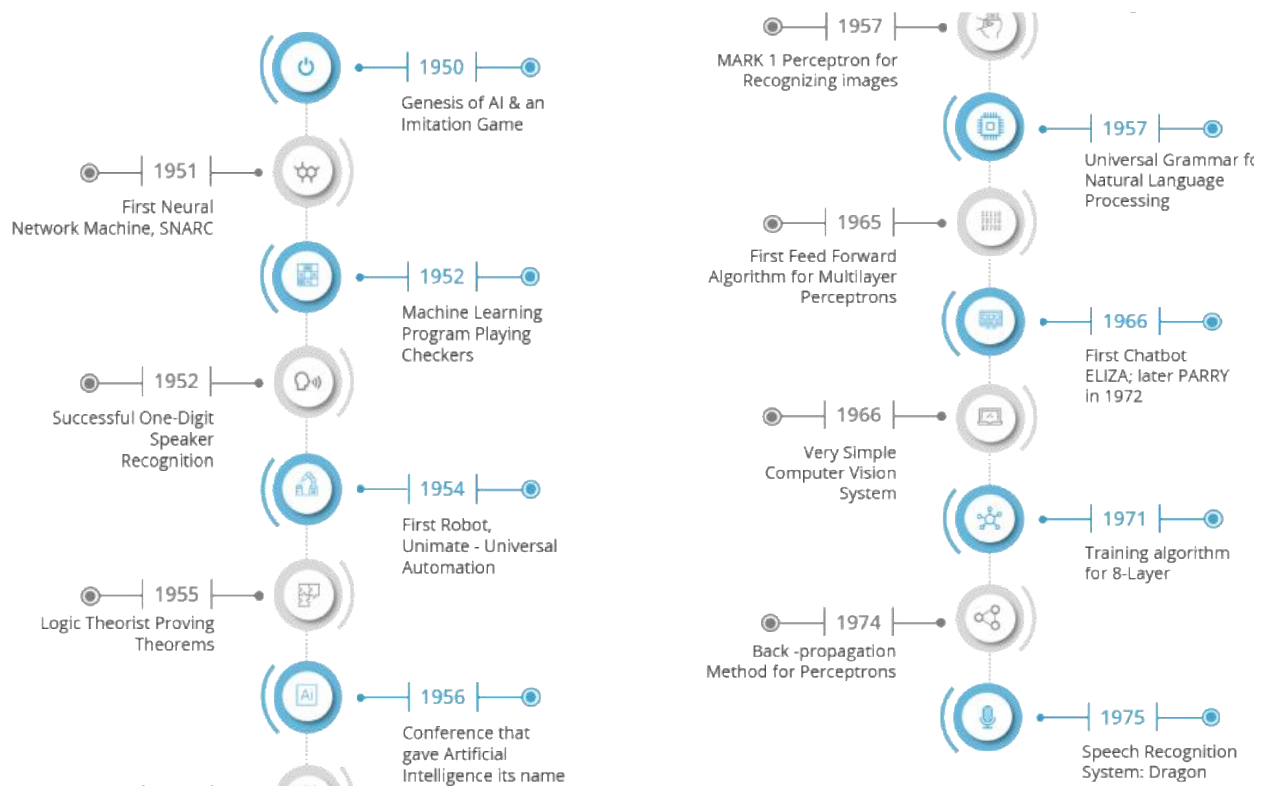
			
John McCarthy	Marvin Minsky	Claude Shannon	Ray Solomonoff
			
Alan Newell	Herbert Simon	Arthur Samuel	

And three others...

- Oliver Selfridge
(Pandemonium theory)
- Nathaniel Rochester
(IBM, designed 701)
- Trenchard More
(Natural Deduction)

More AI History

Many people believe that AI is a relatively recent invention and has resulted in an ongoing and continuous boom. Actually, AI has a long and winding history of booms and busts - known as AI Winters. One nice summary of the early days (i.e. 1956 – 1974) is provided in the diagram below:



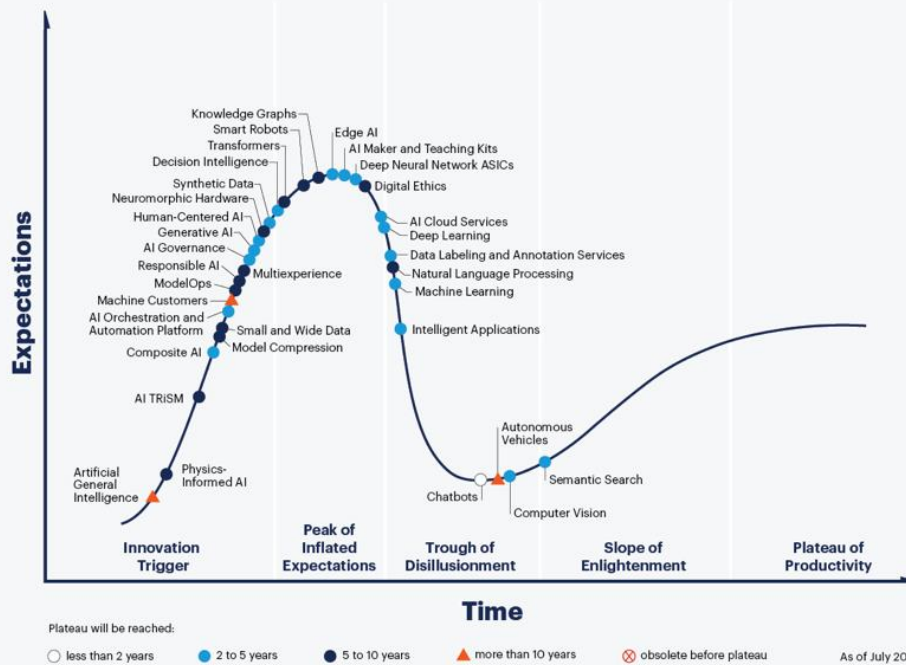
AI Winters

The AI boom has not been a continuous cycle. Indeed, a situation known as “AI Winter” has recurred several times with two major downturns and several other lesser downturns. Like many pivotal technologies, AI has gone through (and continues to go through) “hype cycles”. Gartner publishes a regularly updated AI Hype Cycle chart with discussion which you can find here

<https://www.gartner.com/smarterwithgartner/2-megatrends-dominate-the-gartner-hype-cycle-for-artificial-intelligence-2020/>

<https://www.gartner.com/en/articles/the-4-trends-that-prevail-on-the-gartner-hype-cycle-for-ai-2021>

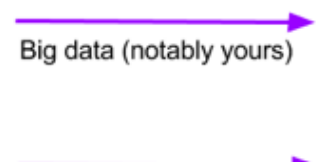
Hype Cycle for Artificial Intelligence, 2021



AI Winters were times when funding was slashed and interest dwindled. There have been two clear winters: from 1974 – 1980 and from 1987 – 1993. **Winters are the result of making bold promises of progress that were not delivered and the pessimism that follows lasts for a number of years.** The first winter came from “grandiose promises not kept”, insider criticism of “connectionism” (now known as neural networks) and the Mansfield Amendment which led to DARPA funding cuts and restrictions

<https://www.nsf.gov/nsb/documents/2000/nsb00215/nsb50/1970/mansfield.html> .

The second winter was the result of the demise of the boom in Expert Systems, the collapse of the special purpose LISP hardware market and the failure of the Japanese 5th Generation computing project (once again grandiose promises made but not kept). The major winters are depicted on the time below.



Question - *Can an AI winter re-emerge in the near future???*

What are Companies doing with AI – a few Application examples

AI has made huge strides since the last AI winter. Here are several examples of recent and important progress (there are many others):

Network security: <https://www.youtube.com/watch?v=ER12XEwci30>

Agriculture: <https://www.youtube.com/watch?v=oot55bK62pk>

NLP/Chatbots: <https://www.youtube.com/watch?v=aNHrLpGQHwA>

Digital Twins for prediction <https://www.youtube.com/watch?v=b6heGJknCvw>

Medical Imaging/healthcare <https://www.youtube.com/watch?v=9fAcjfnWyso>

Autonomous Vehicles: <https://www.youtube.com/watch?v=UdOxt11ofjQ>

Quality control/inspection <https://www.youtube.com/watch?v=L7LtNabIZw0>

Alexa and Conversational AI <https://www.youtube.com/watch?v=sj1t3msy8dc>

Fashion/Clothing Retail <https://www.youtube.com/watch?v=5BMj01SLXKQ>

The Big Picture – So Why is AI So Important Anyway?

This week we will discuss three lines of reasoning about the fundamental importance of AI as a **both** a business and technological prerogative: (1) the 4th industrial revolution /electricity theory; (2) the McKinsey Next Digital Frontier theory and (3) the AI as fundamental business transformer theory

According to some, we are in the midst of the 4th Industrial Revolution

1st revolution
Water/Steam



2nd revolution
Electricity



3rd revolution
Automation



4th revolution
Cyberphysical
systems



This revolution is defined as:

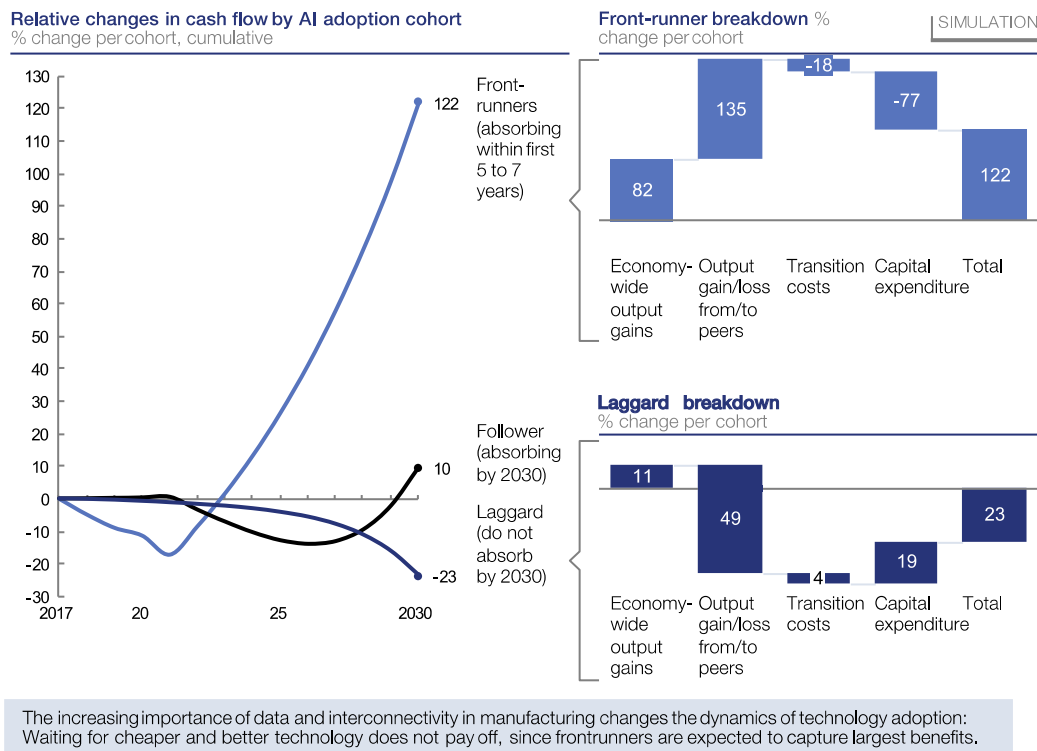
a way of describing the blurring of boundaries between the physical, digital, and biological worlds. It's a fusion of advances in artificial intelligence (AI), robotics, the Internet of Things (IoT), 3D printing, genetic engineering, quantum computing, and other technologies. It's the collective force behind many products and services that are fast becoming indispensable to modern life. Think GPS systems that suggest the fastest route to a destination, voice-

activated virtual assistants such as Apple's Siri, personalized Netflix recommendations, and Facebook's ability to recognize your face and tag you in a friend's photo. This is paving the way for transformative changes in the way we live and radically disrupting almost every business sector. It's all happening at an unprecedented, whirlwind pace -- according to Salesforce

youtube discussions on this <https://www.youtube.com/watch?v=TZyzI7ojsho>
<https://www.youtube.com/watch?v=5KLkNzb0MKo>

Arguably, AI will play such an important role in this revolution that we will see a trifurcation of the economy into “leaders”, “followers” and “laggards” with the lion's share of the benefits accruing to the leaders

http://www3.weforum.org/docs/WEF_4IR_Beacons_of_Technology_and_Innovation_in_Manufacturing_report_2019.pdf sources: WEF and McKinsey



question – why is there an early dip for the “leaders” and a late dip for the “laggards”??

An analogous approach to thinking about the big picture comes from the likes of Andrew Ng and Eric Brynjolfson.

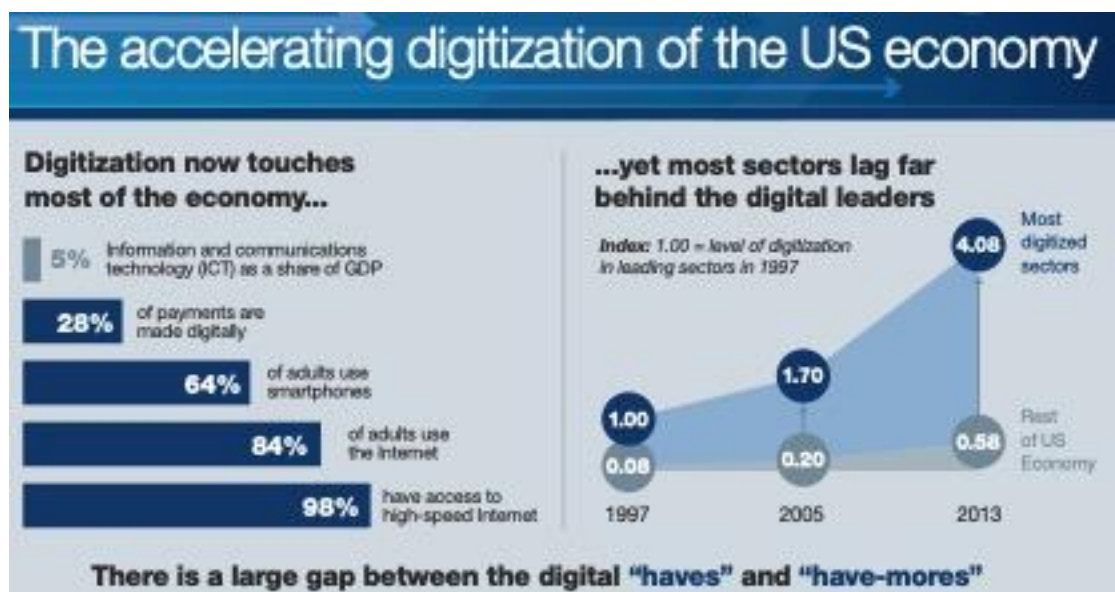
Ng has done a series of talks entitled *AI is the New Electricity* <https://www.youtube.com/watch?v=21EiKfQYZXc&t=373s> (start at minute 3:00 to minute 8:00) and Brynjolfson has done a talk entitled *Why and How to Rethink Business and Society in a Digital Age* <https://www.youtube.com/watch?v=Si8y1Dmze4I> (watch minute 1:00 – 6:30)

Following McKinsey

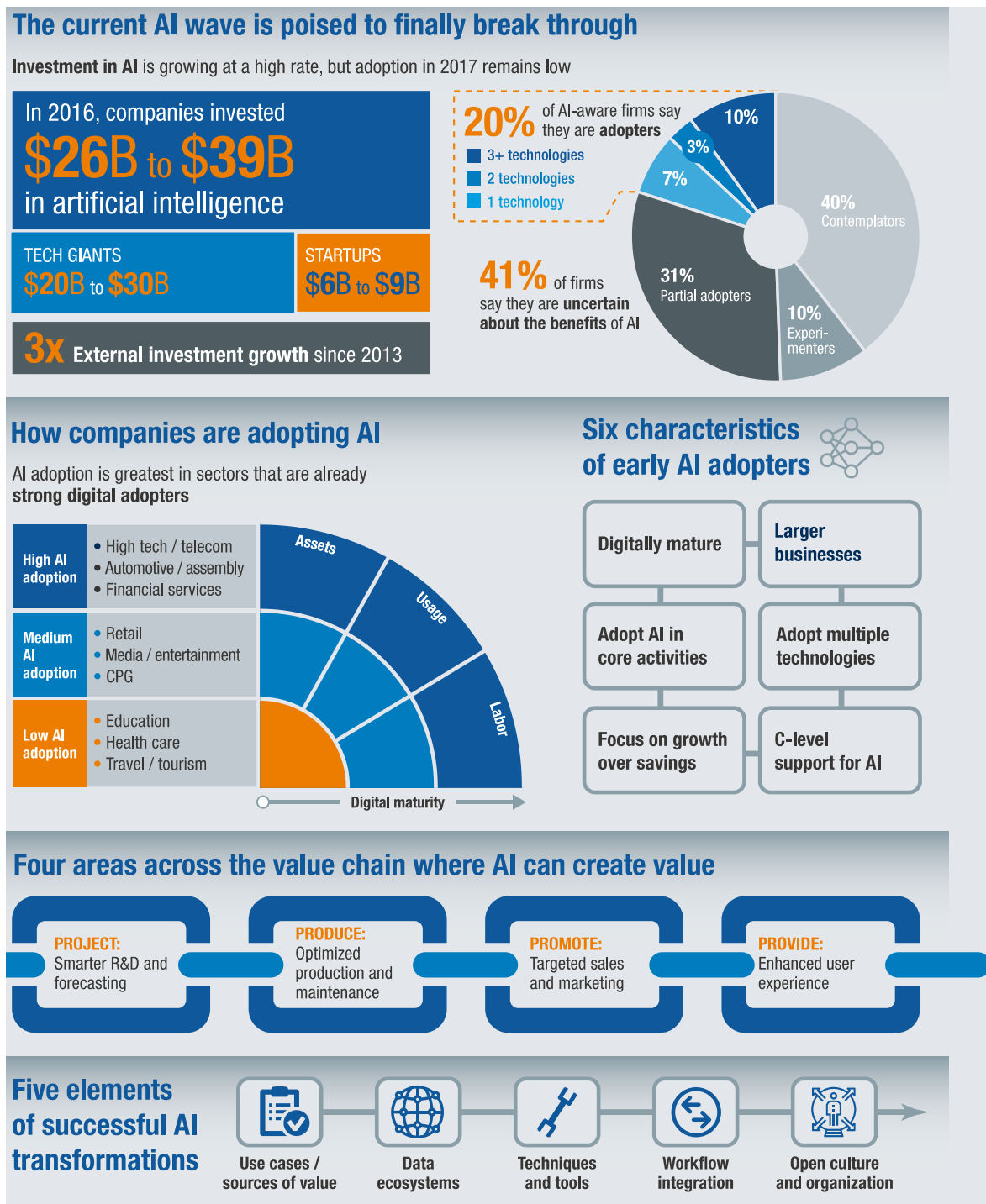
An additional perspective can be gained from a close reading of the works of the consulting company McKinsey for three reasons: (1) they are the most influential consulting company to large corporates in the USA and perhaps the world; (2) they are in many ways pioneers in analyzing this area and have been writing AND releasing articles on both AI and Data Science since 2011; and (3) much of what they have to say has proven over time to be quite insightful. We will examine two examples of the work – the first from 2017 entitled *Artificial Intelligence – the Next Digital Frontier?* and the second a very recent work entitled *The State of AI in 2021*. But first, some preliminary perspective.

The Underpinnings

The key underpinning is the scale and scope of digitization. An early McKinsey paper (circa 2015) entitled *Digital America – a Tale of Haves and Have Mores* illuminated the situation and provided the construction of the Digitization Index. Here is a youtube on the topic <https://www.youtube.com/watch?v=hboFgWVyiKA>



Subsequently, the article *AI - the Next Digital Frontier?* was released in 2017. The short story of the conclusions is captured in the diagram below.



In addition, there is the McKinsey article *The State of AI in 2021* which can be found in animated form here

<https://www.mckinsey.com/business-functions/mckinsey-analytics/our-insights/global-survey-the-state-of-ai-in-2021>

Look carefully through this document including watching the 4 embedded videos.

The state of AI in 2021

As business's adoption of AI continues to grow, the companies reaping the biggest bottom-line benefits are differentiating themselves through their use of more sophisticated tools and practices.

The results of our latest McKinsey Global Survey on AI indicate that AI adoption¹ continues to grow and that the benefits remain significant—though in the COVID-19 pandemic's first year, they were felt more strongly on the cost-savings front than the top line. As AI's use in business becomes more common, the tools and best practices to make the most out of AI have also become more sophisticated.

We looked at the practices of the companies seeing the biggest earnings boost from AI and found that they are not only following more of both the core *and* advanced practices, including machine-learning operations (MLOps), that underpin success but also spending more efficiently on AI and taking more advantage of cloud technologies. Additionally, they are more likely than other organizations to engage in a range of activities to mitigate their AI-related risks—an area that continues to be a shortcoming for many companies' AI efforts.

Broadly speaking, the most significant conclusions are as follows:

- AI adoption is continuing its steady rise (in at least one function) with the highest adoption rate increases in “emerging economies”. I would note that McKinsey puts both China and India in this category... and they may be accounting for much of the increase
- AI use cases now span a range of functional activities led by service operations, product/service development, marketing and sales and risk related activities (e.g. fraud analysis). Use cases related to supply chain management, manufacturing, corporate finance and human resources brought up the rear
- AI has had an **increasing impact over time on driving cost decreases** across functional areas
- AI had a much more **mixed impact on driving revenue increases** across functions but it should be noted that the data was gathered during pandemic times

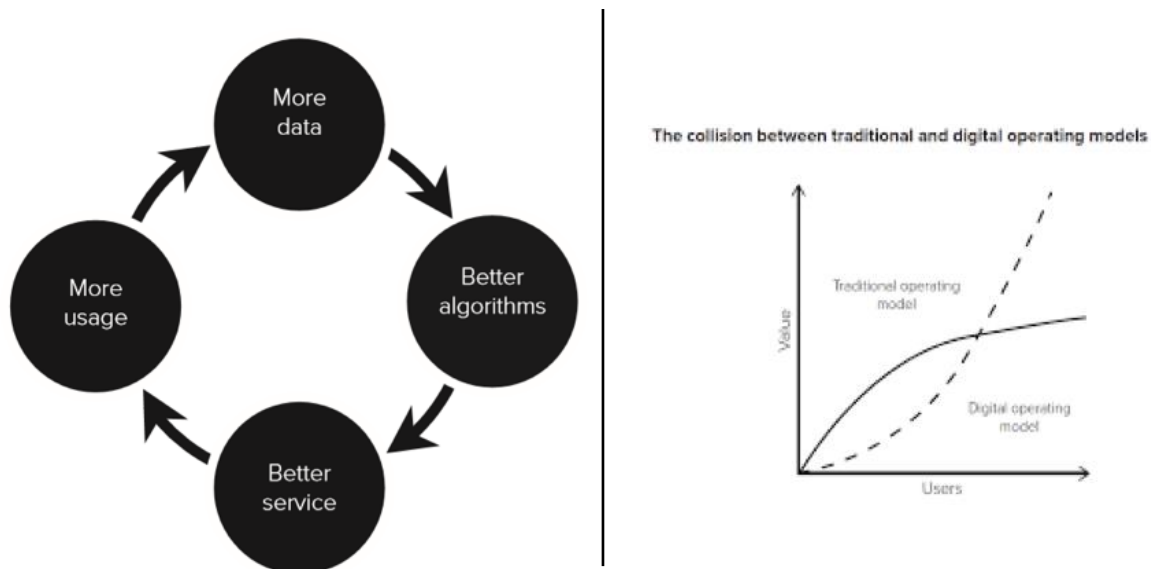
- McKinsey was able to find metrics to designate a key group of companies as **AI high performers** (those attributing at least 20% of EBIT to AI). The high performers were much more active implementers of the so-called AI core practices AND the AI advanced practices as well e.g. a set of best practices now known as MLOps <https://ml-ops.org> for building and deploying Machine learning-based applications
- The AI High Performers were much better at making AI model building and subsequent implementation expenditures efficient and predictable. They also utilized a wider range of AI capabilities (such as Natural language/speech and facial recognition) often via public cloud infrastructure. This once again indicates a further separation between High Performers from the rest in terms of Digital maturity and AI-driven benefit gains
- Risk management seems to be an area which is surprisingly under-emphasized given the ongoing issues with cybersecurity and the potential ramifications on corporate reputation and ongoing issues such as privacy and explainability. Once again, the High Performers stood apart from the rest in key areas such as testing data, measuring model accuracy and thorough model documentation

The final theory is that of Iansiti and Lakhani which argues that AI is a fundamental business transformer. They argue that Digitization + AI brings along a new infrastructure architecture as depicted below

digital backbone	data	algorithms	AI	analytics
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This architecture then becomes the backbone/fabric of the **entire company** instead of merely an IT exercise and results in the fundamental transformation of the company in terms of: (1) The nature of operations, (2) The underlying business model(s), and (3) The nature and basis of competition

The nutshell of the impact is depicted in the diagrams below



The image on the left is called a **Data Flywheel** – the more data that is gathered and accumulated, the more that algorithms (e.g. Machine Learning) can be tuned and improved. This in turn leads to better customer service (and additional features/services) which then drives more usage. The image on the right suggests that the new architecture allows companies to continue to scale users and services with much more efficiency than was previously possible. What perhaps remain unstated is that this will also have the effect of “removing humans from the loop”. Examples include:

- At ANT, 10K employees handle 700M customers vs. Bank of America with 209K employees handling 67M customers
- 3/1/0 of MyBank – 3 minutes for a loan application, 1 second for approval and 0 people involved in the process

Iansiti and Lakhani argue that the ultimate impact is the division of companies into three categories (*does this sound familiar?*)

- **Digital natives** – new breed of company designed from the ground up around AI architecture. Company capable of leveraging data to continuously learn customer needs and improve/create capabilities (Uber, Moderna, etc.)
- **Flexible Legacy** (e.g. Walmart, Microsoft, Google) – companies from a previous generation that were able to make the transition to the current AI environment
- **Evaporated Legacy** (e.g. Blockbuster, Nokia) – formerly well known and successful companies that were unable to make the transition

Illustrative example: Recommendation Engines (RE)

Watch the NetFlix RE youtube to get a little background

<https://www.youtube.com/watch?v=f8OK1HBEgn0> and here is a much longer youtube <https://www.youtube.com/watch?v=IByC2keY3vo>

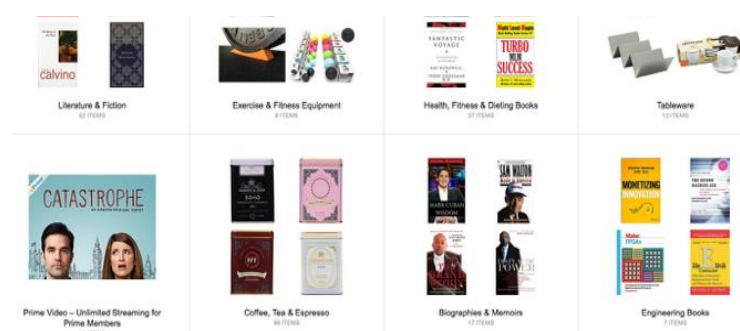
Recommendation engines (REs) have been a minimally hyped but key early win for AI both in the technological sense as well as the economic sense. What are REs? According to Wikipedia they are “a system that seeks to predict the rating or preference a user would give to an item”

https://en.wikipedia.org/wiki/Recommender_system . A more commercial definition comes from Intel literature – “leverage algorithms that help users find products/services based on criteria such as preferences and buying behavior”. Here are some examples:

- Amazon – *customers buying this item often bought these other items*
- NetFlix – *other movies, TV shows you may enjoy*
- YouTube – *recommend videos and songs and generate playlists*
- Facebook – *people you may know, targeted content*
- LinkedIn – *jobs that may interest you or people that you may know, talent search for companies (recruiter replacement)*
- Google News - *news stories of interest*
- Various dating sites – *potential partners*

The bottom line business benefits have quickly become clear. Customers are directed towards items and content that they like but might not have otherwise found/been aware of; **sales are scaled without scaling expenses** (e.g. salespeople); customer retention is better, etc.

The following are quite familiar to hundreds of millions of users:



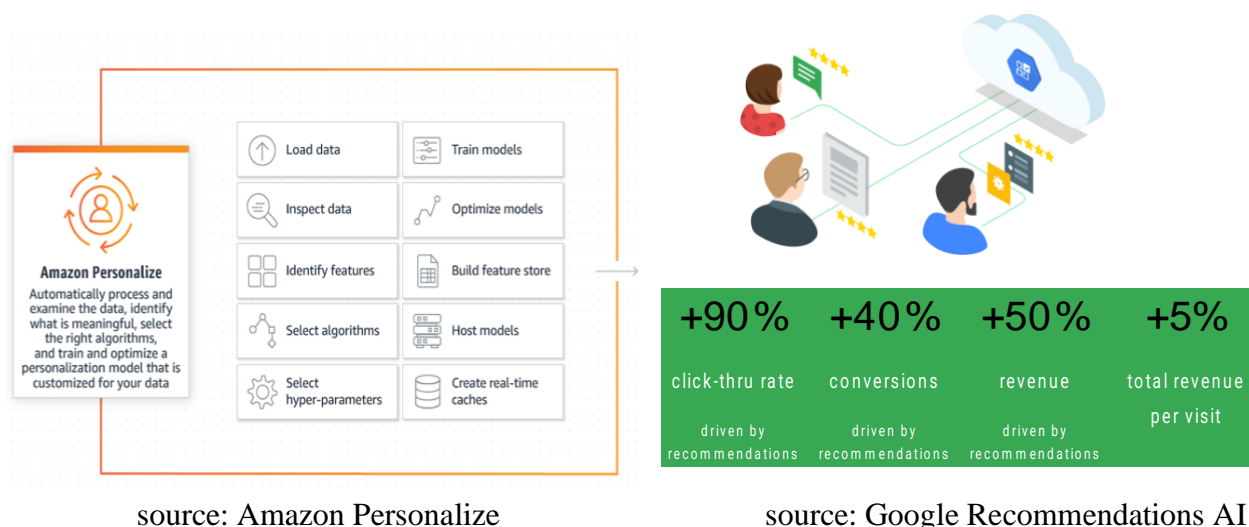
source: Amazon



source: NetFlix

On the technology side, REs have leveraged several different algorithmic approaches including machine learning/deep learning and have been scaled to gracefully handle some of the largest scale applications on the Internet ranging from Amazon and Google to Facebook and NetFlix. There has also supposedly been quantifiable business impact with a number of reports such as the following: “35% of Amazon revenue driven by RE suggestions”; “75% of what people watch on NetFlix driven by RE suggestions”; “20% uptick in conversion rates by Alibaba” and the IDC prediction of on the order of “\$5B spending by the retail and banking industries alone on AI technology with half going to recommendation systems and shopping advisors”.

It is very important to observe that REs are already transitioning to the next phase – they are being offered as managed services both by Google <https://cloud.google.com/recommendations/> and by Amazon <https://aws.amazon.com/personalize/> as depicted in the diagram below:



Note that in the Google “collateral” there are already (heavily caveated) claims about the business benefits of REs derived from driving increases in click-through, conversions, revenue and revenue per visit.

REs also provided us with a nice example of the power of Big Company AI. The leaders such as Amazon and Google have created the technology. They then have benefitted from the heavy usage of the technology for internal and customer facing applications. They then proceed to offer the technology as a managed service. They reap the benefits of the managed service in terms of increased revenue but also in scale and increased learning, which in turn drives further technological improvements (a **data flywheel**). REs also provide an example of the value of

increasingly pervasive sources of data for use in making recommendations – the more data feeds that are available, the more a Google or Amazon can tune and target the recommendations.

What Could Go Wrong???

A headline from a recent article is below and here is the article

<https://medtelligence.net/news/machine-learning-is-booming-in-medicine-its-also-facing-a-credibility-crisis/1922602/>

Machine learning is booming in medicine. It's also facing a credibility crisis

The mad dash accelerated as quickly as the pandemic. Researchers sprinted to see whether artificial intelligence could unravel Covid-19's many secrets — and for good reason. There was a shortage of tests and treatments for a skyrocketing number of patients. Maybe AI could detect the illness earlier on lung images, and predict which patients were most likely to become severely ill.

Hundreds of studies flooded onto preprint servers and into medical journals claiming to demonstrate AI's ability to perform those tasks with high accuracy. It wasn't until many months later that a research team from the University of Cambridge in England began examining the models — more than 400 in total — and reached a much [different conclusion](#): Every single one was fatally flawed.

What went wrong? What can be done to fix it??

The Unexplained and The Explained

As AI expands and diffuses (especially into “mission critical” applications) then people will begin to ask why and how the AI reached the conclusions at hand. Read the following article written by Will Knight, *The Dark Secret at the Heart of AI* <https://www.technologyreview.com/2017/04/11/5113/the-dark-secret-at-the-heart-of-ai/> Answer the questions: *what are the main points? How should we hold the AI accountable for its decisions? Why is it hard for the machine to explain its decision process? What was the story of Deep Patient? When/where might Deep Learning go wrong? Why has the military taken a particularly strong interest? Do we know how to explain human behavior?*

Here is a much more recent follow-on article from Will Knight on the same topic *An AI Pioneer wants his Algorithms to Understand the “Why”*. Will Knight, Wired Magazine. <https://aiws.net/practicing-principles/modern-causal-inference/augmenting/on-media-augmenting/an-ai-pioneer-wants-his-algorithms-to-understand-the-why/>

Here is an article from a different perspective on the same topic. *Explainable AI; Opening the Black Box or Pandora’s Box?* Storey, Parsons and Lukyanenko Communications of the ACM, April 2022. What do they suggest are key issues and pitfalls?? <https://cacm.acm.org/magazines/2022/4/259398-explainable-ai/fulltext>

End Notes

Let's close by reconsidering the big picture. We've gone over the "AI is the new electricity" analogy. Another somewhat similar analogy is that "Data is the new Oil". Here is a representative (although dated) article from the Economist

Leaders

May 6th

2017 edition

Regulating the internet giants

The world's most valuable resource is no longer oil, but data

The data economy demands a new approach to antitrust rules



The entire article is posted at this link

<https://static1.squarespace.com/static/576007632b8ddee314f02a2f/t/5c67cc91eef1a1de5bff30ad/1550306450901/The+world's+most+valuable+resource+is+no+longer+oil%2C+but+data+-+Regulating+the+internet+giants.pdf>

Read this article over carefully and we will discuss the main points and implications in class.

Questions: (1) so why is Data being touted as being so important? (2) by the way – what happened to the oil industry since its peak days??

The Framework for the Course

We will spend the remainder of the course exploring AI based on the multi-layered framework which is depicted below. You will be seeing this image in every class so have a close look and gain a deep understanding.

