MMC VENTURES

The State of AI 2017

# Inflection Point

in association with

Numis

## MMC Ventures

Founded in 2000, MMC Ventures is a research-driven venture capital firm investing in high-growth technology businesses. MMC has backed more than 50 enterprise software and consumer internet companies that have the potential to change the future of financial services, the workplace and retail.

MMC invests on behalf of private and institutional investors. MMC has over £200 million under management and is investing approximately £25 million annually.

MMC's portfolio includes: Appear Here, Bloom & Wild, CloudSense, Elder, Gousto, Interactive Investor, Masabi, NewVoiceMedia, Signal Media, SafeGuard, Sky-Futures, Small World FS and Tyres on the Drive.

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## Numis

Numis is the UK's leading mid market investment bank with a focus on high growth companies both in the listed and unlisted equity markets. Numis has the no. 1 rated equity research team, the leading market share in UK equity issuance and the most UK listed corporate clients, at 200, of any investment bank. In 2015, Numis formalised its efforts in the unlisted market with the formation of its Venture Broking team and its investment in Crowdcube, the largest UK investor in seed and stage A companies.

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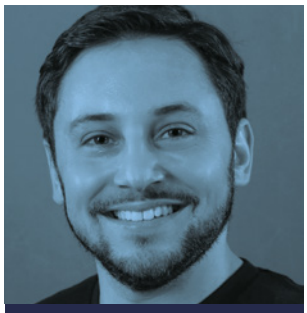
# The State of AI 2017: Inflection Point



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MMC Ventures

Artificial Intelligence (AI) has been described as "the ultimate breakthrough technology" (Satya Nadella, Microsoft). Five of the world's ten most valuable companies – Alphabet (Google), Amazon, Apple, Facebook and Microsoft – are repositioning to become AI-first organisations. While the last ten years have been about building a world that is mobile-first, "in the next ten years, we will shift to a world that is AI-first." (Sundar Pichai, Google).

While hype around AI is at a peak, and some expectations may exceed results in the short term, we believe AI represents a paradigm shift in technology that warrants the attention it is receiving. In 2017 AI reached an inflection point, driven by milestones in investment, capability, entrepreneurship and adoption. The implications for consumers, companies and society will be profound.

Our inaugural State of AI report for 2017 is intended to inform and empower corporate executives, entrepreneurs and investors. While accessible and jargon-free, it draws on new data and over 400 discussions with ecosystem participants to go beyond the hype and explain the reality of AI today, what is to come and how to take advantage. Every chapter includes actionable recommendations for executives, entrepreneurs and investors.

**In 2017 AI reached an inflection point, driven by milestones in investment, capability, entrepreneurship and adoption.**

### In Part 1, we provide an accessible introduction to AI for the non-specialist.

- We explain how AI is a way for software to perform difficult tasks more effectively, by learning through practice instead of following rules.
- We describe why AI is important. For the first time, traditionally human capabilities can be undertaken in software efficiently, inexpensively and at scale.
- AI capability has reached an inflection point. We explain why, after seven false dawns since the 1950s, AI technology is coming of age.

### In Part 2, we explain the applications, implications and adoption of AI.

- AI has numerous, tangible use cases. We highlight 31 across eight sectors and highlight why some sectors, such as financial services, will be affected more than others.
- We explain the profound implications of AI. AI will cause shifts in sector value chains, require new competencies from companies, change companies' competitive positioning, disrupt business models and accelerate cycles of innovation. We also explore AI's potential benefits and harms to society, from improved health to risks of job displacement and increased conflict.
- The adoption of AI has reached an inflection point, moving from innovators and early adopters to the early mainstream. We describe buyers' awareness, understanding and spending intentions regarding AI, highlight sectors leading AI adoption and identify which will be next. We also explain the dynamics of corporate AI adoption. How are companies deploying AI, who is making the decisions and what are the key inhibitors?

**We draw on new data and 400 discussions with ecosystem participants to go beyond the hype and explain the reality of AI today, what is to come and how to take advantage.**

### In Part 3, we explore the ecosystem of early stage AI companies in the UK.

- We map 400 innovative, early stage AI software companies in the UK and highlight key dynamics. AI entrepreneurship is thriving – a new AI company is founded every five days – but focus is uneven, with areas of competition and opportunity. Nearly two thirds of companies are at the earliest stages of their journeys, and their path to monetisation can be longer. We also highlight 11 of the UK's leading early stage AI companies.
- We explore UK AI in a global context. UK AI startups comprise nearly half of the European total, and UK companies are less embryonic than their European counterparts. UK entrepreneurs are embracing AI; a higher proportion of startups in the UK focus on AI than in Europe or even the US.
- Capital dynamics for AI startups are unusual. We discover that investments into early stage AI firms are 20%-50% larger than average and explain why.
- We hear from 11 of the UK's leading AI entrepreneurs. They explain how AI will impact the future, how buyers can maximise value when engaging with startups, the biggest challenges they face when developing AI, and the key success factors for AI entrepreneurship.

### In Part 4, we explain how investors can identify promising early stage AI companies.

- The AI paradigm shift presents opportunities to invest in disruptive early stage software companies as well as public companies developing competitive advantage. We are entering a second wave of AI investment, with capital being allocated to developers of vertical applications.
- We provide an investment framework that describes success factors for early stage applied AI companies. Spanning value potential, value realisation and defensibility, the 16 factors provide a guide for investing in AI and a framework for early stage companies to assess their strengths and challenges.

**In the next ten years, we will shift to a world that is AI-first.**

**Sundar Pichai, Google**

At MMC Ventures, AI is a core area of research, conviction and investment. In the last 12 months we've made eight investments, comprising 54% of the capital we've invested in that time, into some of the UK's most promising AI companies. If you're an early stage AI company, get in touch to see if we can accelerate your journey.

Previous industrial revolutions stemmed from the ability to create or move power, goods or information. Today, as we enter the fourth industrial revolution, value creation lies in the processing of information. AI's ability to process information more intelligently will create benefits both humble and historic. Welcome to the end of the beginning.

"At Numis, we recognise the potential of AI and other transformative technologies. In 2015 we formed our Venture Broking team to engage with high growth private UK companies and help the next generation of leading companies leverage our Number 1-rated public market research and 200 corporate broking relationships." **Nick James** Technology and Venture Research, Numis

# Summary

## Part 1: An introduction to AI

### 1. What is AI?

- Artificial Intelligence ('AI') is a general term that refers to hardware or software that exhibit behaviour which appears intelligent.
- Basic AI has existed since the 1950s, via rules-based programs that display rudimentary intelligence in limited contexts.
- Rules-based systems are limited. Many real-world challenges, from making medical diagnoses to recognising objects in images, are too complex or subtle to be solved by programs that follow sets of rules written by people.
- Excitement regarding modern AI relates to a set of techniques called machine learning, where advances have been rapid and significant. Machine learning is a sub-set of AI.
- Machine learning enables programs to learn through training, instead of being programmed with rules. By processing training data, machine learning systems provide results that improve with experience.
- Machine learning can be applied to a wide variety of prediction and optimisation challenges, from determining the probability of a credit card transaction being fraudulent to predicting when an industrial asset is likely to fail.
- Deep learning is a subset of machine learning that is delivering breakthrough results in fields including computer vision and language.
- Deep learning emulates the way animals' brains learn subtle tasks – it models the brain, not the world. Networks of artificial neurons process input data to extract features and optimise variables relevant to a problem, with results improving through training.

### Recommendations

**Executives**

» Familiarise yourself with the concepts of rules-based software, machine learning and deep learning.
» Recognise that machine learning represents a paradigm shift in software development that offers new possibilities and will impact your organisation.

**Entrepreneurs**

» Explore the concepts of machine learning and deep learning, the benefits they offer, and how they are being applied to solve problems in a range of sectors (Chapter 4).

**Investors**

» Ensure leaders at existing portfolio companies are familiar with the concepts of machine learning and deep learning, given their importance.
» Familiarise yourself with different approaches to machine learning, including random forests, Bayesian networks, support vector machines and deep learning, to differentiate between companies deploying meaningful machine learning and others.

**Machine learning enables programs to learn by training, instead of being programmed with rules.**

## 2. Why is AI important?

- Increasingly, AI enables traditionally human capabilities – understanding, reasoning, planning, communication and perception – to be undertaken by software effectively, efficiently and at low cost.
- General analytical tasks, including finding patterns in data, that have been performed by software for many years can also be performed more effectively using AI.
- New possibilities enabled by AI include: autonomous vehicles; automated medical diagnosis; voice input; intelligent agents; automated data synthesis; and enhanced decision-making.

### Recommendations

**Executives**

» Explore the new possibilities enabled by AI to appreciate the importance AI will have in the decade ahead.
» Familiarise yourself with the five fields of AI research we describe. Identify core aspects of your company's value proposition – for example, planning or communication – to which AI could be relevant.
» The new possibilities enabled by AI will have secondary consequences. Read Chapter 5 to understand the implications of AI.

**Entrepreneurs**

» Explore opportunities, within your own organisation and for customers, to apply progress in the five fields of AI research we describe to solve intractable problems and ease difficult ones.
» Given the importance AI will have in the decade ahead, explore best practices for developing an AI capability (Chapter 9).

**Investors**

» Recognise that although AI is hyped, the possibilities it enables are significant.
» Seek companies that are using AI to fulfil new possibilities. The paradigm shift to AI will create large new winners.

## 3. Why is AI coming of age?

- After seven false dawns since its inception in 1956, AI technology has come of age.
- The capabilities of AI systems have reached a tipping point due to the confluence of seven factors: new algorithms; the availability of training data; specialised hardware; cloud AI services; open source software resources; greater investment; and increased interest.
- Together, these developments have transformed results while slashing the difficulty, time and cost of developing and deploying AI.

### Recommendations

**Executives**

» Be aware that AI technology has come of age and will be a key enabler, and potential threat, in the coming decade.
» Familiarise yourself with the seven enablers of AI, the applications of AI (Chapter 4), and the implications of AI (Chapter 5) to lead and contribute to AI initiatives in your organisation.

**After seven false dawns since its inception in 1956, AI technology has come of age.**

## Summary

**Entrepreneurs**

» AI technology can deliver tangible benefits today. Look for opportunities to incorporate AI in your software, where appropriate, whether or not you are an 'AI company'.

» Explore AI infrastructure and services available from Google, Amazon, IBM and Microsoft, as well as open source machine learning libraries. They enable experimentation with AI at speed and low cost.

**Investors**

» AI will be a powerful tool for existing portfolio companies – and a threat. Evaluate whether portfolio companies are embracing AI as a means of competitive advantage.

» With AI technology at a tipping point, seek opportunities to invest directly or indirectly in companies taking advantage of AI.

# Part 2: The applications, implications and adoption of AI

## 4. The applications of AI

- AI has numerous, tangible use cases today that are enabling corporate revenue growth and cost savings.
- The capabilities of AI – its power to incorporate broader data sets into analyses, identify concepts and patterns in data more effectively, and enable human-to-machine conversation – will have application in all sectors and numerous business processes.
- Applications will be most numerous in sectors in which a large proportion of time is spent collecting and synthesising data: financial services; retail and trade; professional services; manufacturing; and healthcare. Applications of AI-powered computer vision will be particularly significant in the transport sector.
- Use cases are proliferating as AI's potential is understood. We describe 31 core use cases across eight sectors: asset management; healthcare; insurance; law & compliance; manufacturing; retail; transport; and utilities.
- We illustrate how AI can be applied to multiple processes within a business function (human resources).

### Recommendations

**Executives**

» Examine AI use cases in a range of sectors to familiarise yourself with the technical capabilities of AI – from incorporating additional data sets into analyses to identifying patterns in data more effectively and understanding written and spoken language.

» Assess the extent to which time is spent collating and processing data in your industry. AI's impact will be greatest in sectors where data synthesis and processing are core.

» Identify business processes in your sector that could be improved, automated or reinvented using AI.

**Entrepreneurs**

» AI offers new opportunities for disruption in sectors ranging from manufacturing to healthcare. Identify business processes ripe for improvement or reinvention through AI, particularly in sectors in which data synthesis or processing are extensive.

» AI has numerous capabilities, from multi-variate analysis to natural language processing. Identify opportunities to use multiple aspects of AI, both within your company and for buyers.

**Investors**

» Evaluate opportunities and threats to portfolio companies from the many applications of AI.

» With AI poised to impact multiple sectors, develop a framework to identify preferred sectors for investment. Considerations are likely to include fundamentals (scope for structural change in a sector) and pragmatic factors (sector expertise).

**AI's value can be abstracted to four benefits: innovation, efficacy, velocity and scalability.**

## 5. The implications of AI

- AI's value can be abstracted to four benefits: innovation (new products and services); efficacy (the performance of tasks more effectively); velocity (the completion of tasks more quickly); and scalability (the extension of capabilities to new market participants).
- By automating capabilities previously delivered by human professionals, AI will reduce the cost and increase the scalability of services, significantly broadening participation in select markets.
- In multiple sectors AI will change where, and the extent to which, profits are made within a value chain.
- New commercial success factors will determine a company's ability to be successful in the age of AI.
- New leaders, followers, laggards and disruptors will emerge as the paradigm shift to AI causes significant shifts in companies' competitive positioning.
- AI, growth of 'x-as-a-service' consumption, and subscription payment models will obviate select business models and offer new possibilities in sectors including transport, insurance and healthcare.
- As AI gains adoption, the skills that companies seek, and companies' organisational structure, will change.
- By reducing the time required for process-driven work, AI will accelerate the pace of business and innovation. This may compress cycles of creative destruction, reducing the period of time for which all but a select number of super-competitors maintain value.
- AI will provide benefits to society including improved health, broader access to services and more personalised experiences. It will also present risks and dilemmas, including issues of job displacement, bias, conflict and privacy.

## Recommendations

**Executives**

» Evaluate how the benefits unleashed by AI – innovation, efficacy, velocity and scalability – will impact your industry.
» Assess the shifts in your industry value chain that will occur as AI adoption grows.
» Evaluate the business model a disruptor might adopt in the age of AI, if freed from the "innovator's dilemma". What would the Netflix to your Blockbuster look like?
» Assess the extent to which your company is developing the commercial success factors, skills and organisational design required for the age of AI.
» Recognise the need for responsible stewardship. AI presents risks to society – including issues of job displacement, bias, and privacy – as well as benefits.

**Entrepreneurs**

» Identify opportunities to take advantage of probable shifts in sector value chains that will be caused by AI.
» Develop initiatives that will take advantage of the new market participants and business models that AI will present.
» Identify weaknesses in incumbents' competitive positioning that are likely to persist, or worsen, given their structure or strategy.

**Investors**

» Assess how the innovation, efficacy and scalability enabled by AI will impact your existing portfolio companies.
» Identify investment opportunities in sectors that will be transformed as a result of AI altering value chains and enabling new market participants.
» Evaluate opportunities to invest in companies structured around business models that will come of age as AI disrupts existing markets.

## 6. The adoption of AI

- Awareness of AI has reached an inflection point. Given media attention and vendor marketing, executives' awareness of AI is high.
- Understanding of AI among buyers is low. Technology principles, use cases and deployment methodologies are poorly understood.
- While nascent, AI adoption is 'crossing the chasm' from innovators and early adopters to the early majority. 20% of AI-aware executives say they have adopted one or more AI-related technology at scale, or in a core part of their business (McKinsey Global Institute).
- Adoption of AI will increase significantly as buyers seek to unlock value from data and avoid losing competitive advantage. 75% of executives say AI will be "actively implemented" to some degree in their organisations within three years (Economist Intelligence Unit).
- High tech, automotive and assembly, and financial service firms lead AI adoption. Spending on AI will increase most in sectors that currently lead adoption.
- Poorly articulated business cases weigh on adoption. Better articulation of ROI by AI vendors can catalyse adoption.
- While numerous pilot projects relate to chatbots, more than two thirds of buyers are deploying AI to improve decision-making and enable process automation.
- For mid-size and large companies, the C-suite is key for initiating, selecting and funding AI initiatives. In two thirds of organisations, the CTO or CIO make AI technology decisions given its cross-functional implications.
- AI deployment strategies are varied, with a mix of 'build' and buy' strategies, and in a state of flux. 'Hybrid' approaches are typical. A quarter of companies deploying AI today prefer to purchase a standalone solution.
- Lack of skills is the primary challenge for companies deploying AI. Defining an AI strategy, identifying use cases for AI, and securing funding for AI initiatives are additional difficulties.

## Recommendations

**Executives**

» Adoption of AI is nascent but has passed a tipping point. Develop an AI strategy to avoid losing competitive advantage.
» Understanding of AI within your organisation is likely to be low. Develop initiatives to improve senior executives' understanding of AI by engaging with third-party experts.
» Engage with AI software companies that articulate tangible use cases and ROI opportunities. Seek vendors offering solutions to business problems, not slogans.
» While chatbots receive extensive attention, recognise that your peers are more likely to be deploying AI to enhance business decision-making and process automation.
» Proactively address the likely challenges to your organisation's adoption of AI: lack of skills, the absence of an AI strategy, lack of clarity regarding AI use cases, and prioritisation of funding.

**Entrepreneurs**

» To address buyers' caution regarding AI technology, articulate solutions to business problems and ROI opportunities, not AI technology as an end in itself.
» Recognise that buyers' understanding of AI is low, and they are likely to lack AI skills and personnel within their organisations. Become a strategic partner for customers by offering education and support.
» Offer buyers improved decision-making and process automation to align with their priorities.
» Given the importance of the C-suite in initiating and funding AI initiatives at large companies, prioritise securing senior sponsorship for your initiatives.

**AI adoption is 'crossing the chasm' from innovators and early adopters to the early majority.**

**Investors**

» AI adoption is nascent, but crossing a tipping point from early adopters to the early mainstream. Identify opportunities to invest in AI-first companies that can capitalise on increasing demand for AI.
» Understanding of AI among buyers is limited, and C-level sponsorship may be required for deployments in large companies. Given these go-to-market dynamics, evaluate management teams' ability to articulate to buyers tangible solutions to business problems, and their C-level account management skills.
» Prospects that provide solutions aligned with buyers' priorities – improved decision-making and process automation – may be most attractive.

## 7. The growth of AI services

- For every £1 spent on enterprise software, £3 is spent on IT services – consulting, system integration and outsourcing.
- IT service companies involved in AI – 'AI service' companies – assist buyers with AI initiatives ranging from reviews of AI strategy to chatbot implementations.
- A focal point for AI service activity is supporting buyers' rollout of analytics software that incorporates AI.
- As mid-size companies and enterprises experiment with AI, most plan to involve a third-party AI service provider, fuelling growth in the AI services market.
- While early and modestly-sized today, the AI services market is poised for rapid growth. As buyers use AI to gain value from historic investments in data collection, we expect AI services to offer a multi-billion-dollar market opportunity by 2020.
- 'Convergence' and consolidation are reshaping the market. Software companies are developing service capabilities to support solution-selling, while service companies are developing and acquiring software assets to access client opportunities and reduce cost to serve.
- The delivery model for AI services is changing. Led by mid-market buyers, we expect a mix shift from traditional projects of fixed scope, to managed services delivered via the cloud, paid for on an ongoing basis.
- Competition for AI services work above the mid-market will be fierce. For large deals, global service firms will leverage their data and data science personnel. Mid-size deals will represent a second battleground, with mid-tier vendors competing with each other and vendors from above and below. For smaller deals, select boutiques offer buyers the right success factors – accessibility, flexibility and low cost – to achieve scale and mature into mid-size vendors.
- Specialisation is becoming a key success factor for competitive differentiation and defensibility. Increasingly, individual AI service providers are focusing their competencies on specific verticals, business functions or business sub-functions.

## Recommendations

**Executives**

» Evaluate opportunities to catalyse time to value in AI by engaging with AI service providers.
» Effective service providers focus on solving business problems, not AI technology for its own sake. Engage with companies that describe clearly how they can improve your key performance indicators, using technology as an enabler.
» Managed service deployments are coming of age. For AI-powered analytics, evaluate whether a third-party solution delivered via the cloud could be suitable.
» Competition for large contracts is fierce. Negotiate robustly with multiple suppliers to maximise value.

**Entrepreneurs**

» Consider offering a managed service capability to take advantage of evolving buyer behaviour.
» Evaluate a specialisation strategy to develop data network effects and competitive differentiation in a competitive market.
» Proactively explore M&A to avoid being left sub-scale in a consolidating market.

## Summary

**Investors**

» Evaluate opportunities for investment in AI services, given potential for strong growth in the market.
» Be cognisant of competitive dynamics and the risk of commoditisation in the market.
» Evaluate whether encouraging portfolio companies to specialise in certain sectors or business functions could support their defensibility.
» Given extensive market consolidation, create and identify opportunities to achieve scale through mergers and realise value through trade sales.

# Part 3: Early stage companies in the UK

## 8. The dynamics of UK AI

- There are nearly 400 independent, early stage software companies in the UK with AI at the heart of their value proposition.
- AI entrepreneurship is thriving. The number of AI companies founded annually in the UK has doubled since 2014. A new UK AI company has been founded every five days, on average, since 2014.
- Over 80% of UK AI startups are vertically-focused business-to-business (B2B) suppliers. Few companies sell direct-to-consumer given the difficulty of acquiring training data from a 'cold start' and the deployment of AI by global consumer technology companies.
- Entrepreneurial activity in AI is unevenly spread. More UK AI companies (one in seven) address the marketing & advertising function than any other. For companies with a sector focus, finance dominates. In select sectors (manufacturing) and business functions (finance), activity appears modest relative to market opportunities.
- Few (one in ten) UK AI startups develop core AI technologies applicable to a wide variety of markets. Among these companies, most focus on research into autonomous systems.
- UK AI companies comprise nearly half the European total. AI is well represented in the UK, with a slightly higher proportion of startups focused on AI than in Europe (excluding the UK) or the US.
- UK AI companies are nascent. Two thirds of companies are in the earliest stages of their journey, with Seed or Angel funding. The sector, however, is maturing rapidly. UK companies are less embryonic than their European counterparts.
- Over 40% of companies we meet have yet to receive recurring revenue. The journey to monetisation for AI companies can be longer given technical challenges, long sales cycles in a B2B-driven market, and client integration requirements.
- Globally, investments into early stage AI firms are typically 20%-50% larger than capital infusions into general software companies of comparable stages.
- Staging of capital into UK AI companies can be atypical. One in three growth stage companies raised a significantly larger post-Angel rounds than is typical.
- We feature 11 leading B2B and B2C AI companies across a range of sectors to illustrate how early stage companies are using AI to address opportunities.

### Recommendations

**Executives**

» Explore the rich ecosystem of early stage AI companies in the UK. Most will be B2B vendors and some will offer market-leading solutions to challenges in your organisation.
» Identify potential suppliers and partners in your sector, and in key business functions.
» Anticipate that many AI companies will be nascent, which may limit their ability to provide customer references and extensive resources.

**Entrepreneurs**

» Identify potential competitors and partners using our market map.
» AI entrepreneurship has accelerated, increasing the number of market entrants and competition. Prioritise customer acquisition in an increasingly crowded market.
» Implement technologies that can reduce the cost and time required to ingest data, process data and deploy your product at client sites, to overcome challenging go-to-market dynamics that are common for early stage AI companies.
» Recognise that capital raises for early stage AI companies are typically larger than for non-AI software companies. Capitalise your business adequately to create and maintain competitive advantage.

**Investors**

» With some segments over-supplied by startups and others under-served, identify attractive pockets of opportunity aligned with themes on which you focus.
» With investments into AI companies larger than average, valuations can be elevated. Consider whether or not you are willing to 'overpay' to access opportunities.
» A significant proportion of AI companies have yet to achieve recurring revenue. Further, a sizeable minority of Angel stage companies are raising larger second rounds than is typical. Evaluate whether you are willing to invest in pre- or low revenue companies to secure access.

## 9. AI entrepreneurs' perspectives

- Entrepreneurs anticipate a new, AI-driven future. AI will improve decision-making and increase automation in every sector and most businesses functions, with profound effects.
- Early stage companies offer buyers innovation and flexibility. Startups enable established companies to harness new technologies, and buyers can shape evolving propositions from early stage companies to their bespoke needs.
- When engaging with early stage companies, buyers can maximise value by adopting a collaborative mindset and simplifying procurement processes.
- Successful AI entrepreneurs deliver solutions, not technology. AI companies should focus on solving a business problem, not on technology as an end in itself. Identifying repetitive, data-intensive problems well suited to AI enables companies to attract clients and address inefficiencies in their own organisations.
- Access to data, scarce talent and difficult productisation processes are key challenges for early stage AI companies. Companies can mitigate these challenges, respectively, by implementing data acquisition strategies early in their journey, building relationships with academic institutions and research communities, and developing feedback loops between development teams and customer success functions.
- Key success factors for AI entrepreneurship are: customer focus; continuous technological evolution; development of data access strategies; long-term planning; and perseverance in this demanding field.

## Recommendations

**Executives**

» Entrepreneurs have a valuable understanding of the AI-enabled future. Engage with them to improve your organisation's understanding of AI, and how its potential could unlock strategic value for your organisation in the long term.
» Early stage companies can be powerful enablers of innovation. Explore opportunities to collaborate with early stage companies by creating horizontal innovation departments and engaging in proof-of-concept projects.
» To maximise value from early stage companies, consider a simplified procurement process, adopt a collaborative mindset, provide continual feedback and expect capabilities to evolve over time.

## Summary

**Entrepreneurs**

» AI has the potential to create value in most business processes and can be a powerful tool for all early stage companies – not just 'AI companies'. Identify opportunities to apply AI to business problems and develop an AI strategy to avoid losing competitive advantage.
» To attract customers and investors, articulate solutions to business problems rather than AI technology as an end in itself.
» Given their importance and difficulty, from the inception of your company develop strategies for data access, AI talent recruitment and productising AI. Plan for the long term.
» View AI as a capability, not a feature. Anticipate ongoing development and resource the initiative accordingly.
» AI can improve your own company's processes as well as customers'. Look within your company for opportunities to automate manual processes and free personnel to focus on client activity.

**Investors**

» Identify founders who combine a profound vision of AI's ability to unlock value with the ability to articulate to buyers down-to-earth solutions that address business challenges.
» Prioritise evaluating AI companies' access to data and ability to attract AI talent, given the importance of these factors to AI companies' success.
» Evaluate the extent to which leadership teams have the necessary domain expertise and account management capabilities to engage with large buyers, given demanding go-to-market dynamics.

# Part 4: Investing in AI

## 10. An investment framework for AI

- The AI paradigm shift presents opportunities to invest in disruptive early stage software companies as well as public companies developing competitive advantage.
- AI acquisitions have increased significantly, averaging ten per month in 2017 (CB Insights).
- A first wave of acquisitions focused on core AI technologies – 'deep-tech' AI research or AI-powered computer vision and language capabilities with cross-sector utility.
- We are entering a second wave of AI investment and exits. Capital is being allocated to developers of vertical applications.
- We provide our AI Investment Framework, which identifies 16 success factors for early stage, applied AI companies. We divide the 16 factors into three categories: value potential, value realisation and defensibility. Applying the success factors helps highlight attractive investment opportunities.
- Keys to value potential are: scope for value release and disruption; unattractive alternatives; suitability of AI to a business problem; a path to acceptable technical performance; and suitability of available data.
- Keys to value realisation are: management commerciality; quantifiability of ROI; buyer readiness; benign regulation; and deployment scalability.
- Keys to defensibility are: distance from AI monoliths' offerings; domain complexity; data network effects; proprietary algorithms; attractive AI talent dynamics; and strong capitalisation.

**AI acquisitions have increased significantly, averaging ten per month in 2017.**

**CB Insights**

## Recommendations

### Executives

- Apply the 16 factors to assess your own organisation's AI capabilities.
- Use the 16 factors to identify strengths and weaknesses, and support due diligence, of AI partners and potential acquisition opportunities.

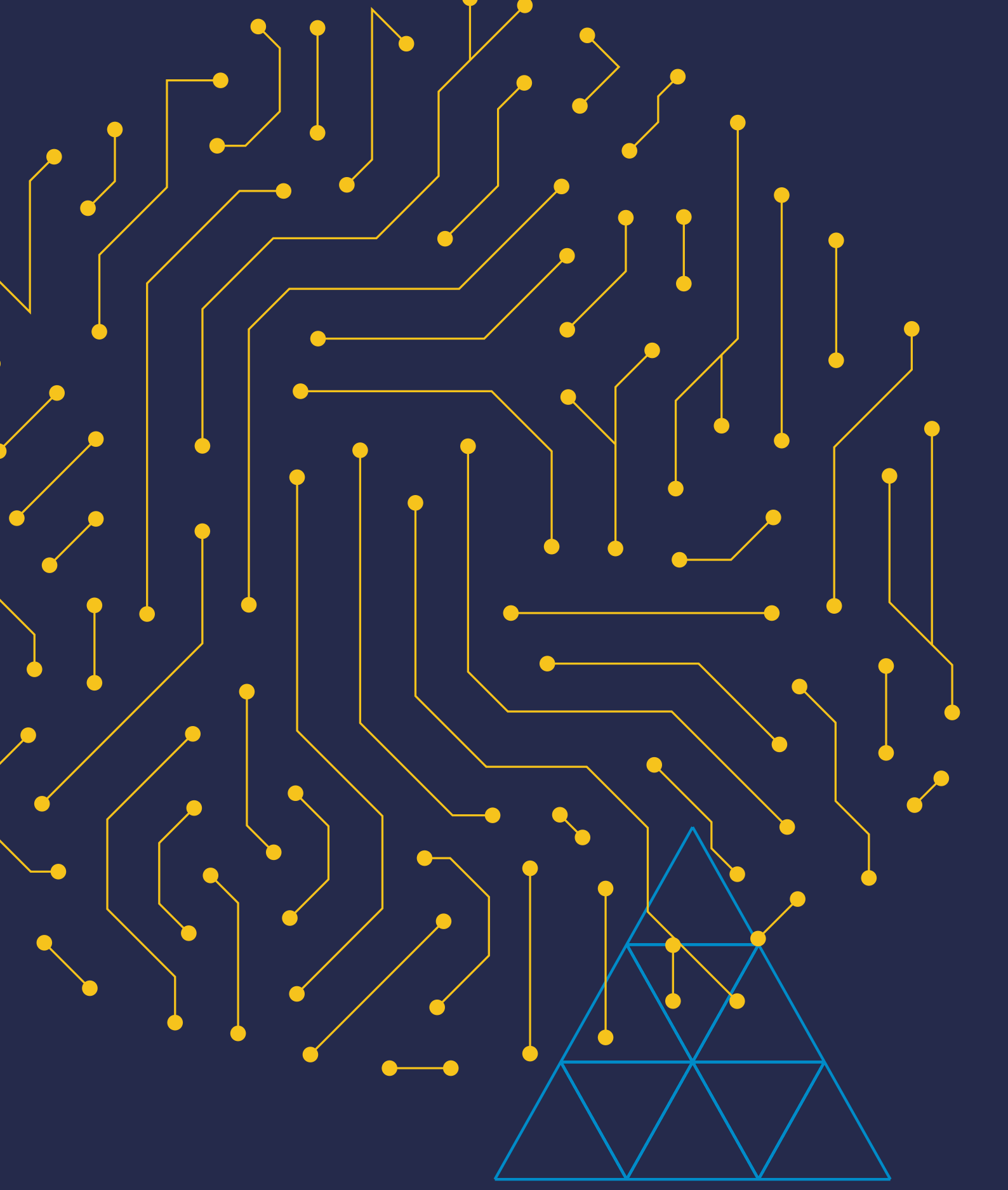
### Entrepreneurs

- Evaluate your company's strengths and weaknesses against the 16 factors.
- Highlight to buyers and investors, as appropriate, your company's strengths in key criteria including value release, management commerciality, quantifiability of ROI, data network effects, AI talent, vertical focus and domain expertise.
- Address headwinds to value realisation by automating deployment requirements, particularly customer data processing, and focusing early on building a capable sales organisation.
- Investors decline to invest in startups due to doubts about management commerciality and tangibility of ROI more than for any other reasons. Focus remediation and messaging on these critical issues.

### Investors

- Consider developing a basket of AI-driven investments.
- Apply the 16 factors, in addition to your usual considerations, to evaluate early stage applied AI companies.
- Remain open-minded to select investment opportunities in horizontal AI providers. While rarer, and with differing dynamics to application providers, companies with world-class technology valuable to an AI platform provider can be an attractive technology or talent acquisition.
- Get in touch with us to discuss your perspective. Where do you agree, or disagree, with our thinking?

**We provide our AI Investment Framework, which identifies 16 success factors for early stage, applied AI companies.**



# Chapter 1

# What is AI?

## Summary

- 'AI' is a general term that refers to hardware or software that exhibit behaviour which appears intelligent.
- Basic AI has existed since the 1950s, via rules-based programs that display rudimentary intelligence in limited contexts. Early forms of AI included 'expert systems' designed to mimic human specialists.
- Rules-based systems are limited. Many real-world challenges, from making medical diagnoses to recognising objects in images, are too complex or subtle to be solved by programs that follow sets of rules written by people.
- Excitement regarding modern AI relates to a set of techniques called machine learning, where advances have been rapid and significant. Machine learning is a sub-set of AI. All machine learning is AI, but not all AI is machine learning.
- Machine learning enables programs to learn through training, instead of being programmed with rules. By processing training data, machine learning systems provide results that improve with experience.
- Machine learning can be applied to a wide variety of prediction and optimisation challenges, from determining the probability of a credit card transaction being fraudulent to predicting when an industrial asset is likely to fail.
- There are more than 15 approaches to machine learning. Popular methodologies include random forests, Bayesian networks and support vector machines.
- Deep learning is a subset of machine learning that is delivering breakthrough results in fields including computer vision and language. All deep learning is machine learning, but not all machine learning is deep learning.
- Deep learning emulates the way animals' brains learn subtle tasks – it models the brain, not the world. Networks of artificial neurons process input data to extract features and optimise variables relevant to a problem, with results improving through training.

# Recommendations

## Executives

- Familiarise yourself with the concepts of rules-based software, machine learning and deep learning.
- Recognise that machine learning represents a paradigm shift in software development that offers new possibilities and will impact your organisation.
- Identify sources of AI expertise, and existing AI projects, within your organisation.
- Explore why AI is important (Chapter 2) and the applications of AI (Chapter 4).
- Understand how peers are deploying AI (Chapter 6) to catalyse next steps.

## Entrepreneurs

- Explore the concepts of machine learning and deep learning, the benefits they offer, and how they are being applied to solve problems in a range of sectors (Chapter 4).

## Investors

- Ensure leaders at existing portfolio companies are familiar with the concepts of machine learning and deep learning, given their importance.
- Explore how the limits of rules-based systems are inhibiting portfolio companies. What problems are too complex, or subtle, to be solved by rules-based systems?
- Familiarise yourself with different approaches to machine learning, including random forests, Bayesian networks, support vector machines and deep learning, to differentiate between companies deploying meaningful machine learning and others.

**AI is a general term that refers to hardware or software that exhibit behaviour which appears intelligent.**

## AI: the science of intelligent programs

Coined in 1956 by Dartmouth Assistant Professor John McCarthy, Artificial Intelligence (AI) is a general term that refers to hardware or software that exhibit behaviour which appears intelligent. AI is "the science and engineering of making intelligent machines, especially intelligent computer programs" (John McCarthy).

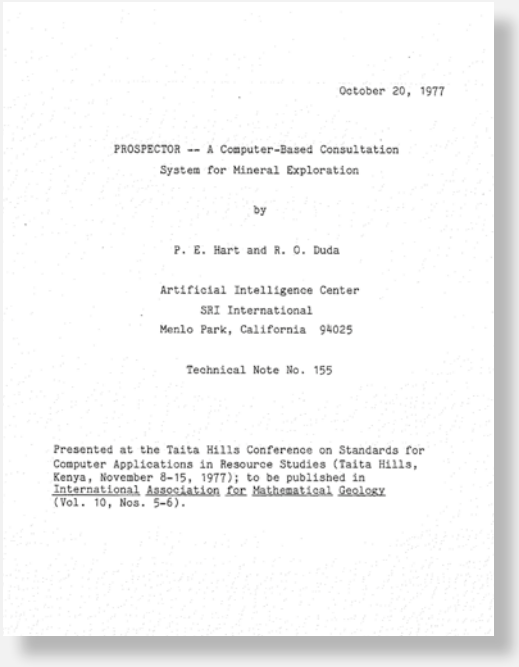
## Early AI: rules-based systems

Basic AI has existed for decades, via rules-based programs that exhibit rudimentary displays of intelligence in specific contexts.

'Expert systems' were a popular early form of AI. Programmers codified a body of knowledge in a specific field and a set of rules designed to emulate an expert's reasoning process, to create a program that would mimic the function of an expert. SRI International's PROSPECTOR system of 1977 (fig. 1) assisted geologists' work in mineral exploration. Incorporating extensive information and over 1,000 rules, the system was intended to emulate the process followed by a geological expert investigating the potential of a drilling site (fig. 2).

While expert systems experienced some success (PROSPECTOR predicted the existence of an unknown molybdenum deposit in Washington State) their capabilities were limited.

**Fig. 1. PROSPECTOR Expert System: 1977 Technical Note (Cover)**



October 20, 1977

PROSPECTOR -- A Computer-Based Consultation System for Mineral Exploration

by

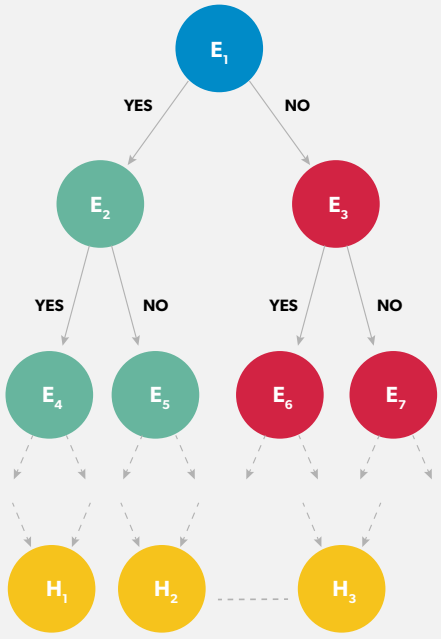
P. E. Hart and R. O. Duda

Artificial Intelligence Center
SRI International
Menlo Park, California 94025

Technical Note No. 155

Presented at the Taita Hills Conference on Standards for Computer Applications in Resource Studies (Taita Hills, Kenya, November 8-15, 1977); to be published in International Association for Mathematical Geology (Vol. 10, Nos. 5-6).

**Fig. 2. PROSPECTOR Expert System: 1977 Technical Note (Detail: Decision Tree)**




Source: SRI International

## The limits of rules-based systems

Rules-based systems are limited, because many real-world challenges are too complex or subtle to be solved by programs that follow sets of rules written by people.

Providing a medical diagnosis, optimising the performance of an industrial asset (fig. 3), or developing an ideal investment portfolio are all complex problems. Each involves numerous data sets, with non-linear relationships between variables. Writing a set of rules that will produce ideal results is extremely challenging.

What if the burden of finding solutions to complex or subtle problems could be transferred from the programmer to the program? This is the promise of modern AI.

**Fig. 3. A complex problem: Industrial asset optimisation**

Source: Alamy

## Machine learning: programs that learn through training

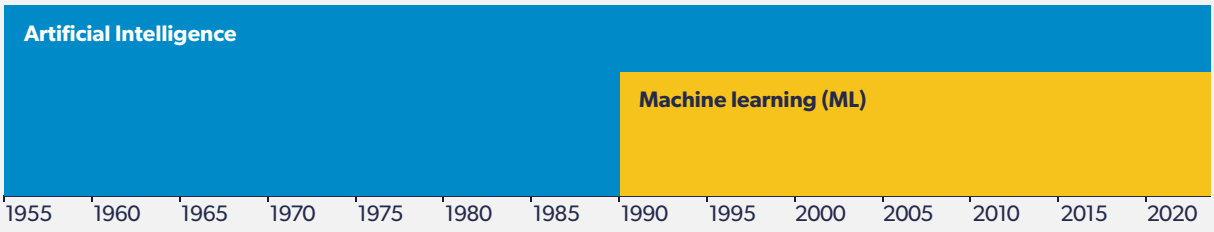
Excitement regarding modern AI relates to a set of techniques called machine learning, where advances have been rapid and significant. Machine learning is a sub-set of AI (fig. 4). All machine learning is AI, but not all AI is machine learning.

Machine learning enables complex or subtle problems to be solved by shifting much of the burden from programmers to their programs. Instead of codifying rules for programs to follow, programmers enable programs to learn. Machine learning is the "field of study that gives computers the ability to learn without being explicitly programmed" (Arthur Samuel).

Machine learning algorithms learn through training. In a simplified example, an algorithm is fed inputs – training data – whose outputs are usually known in advance ("supervised learning"). The algorithm processes the input data to produce a prediction or recommendation. The difference between the algorithm's output and the correct output is then determined. If the algorithm's output is wrong, the processing function in the algorithm changes to improve the accuracy of its predictions.

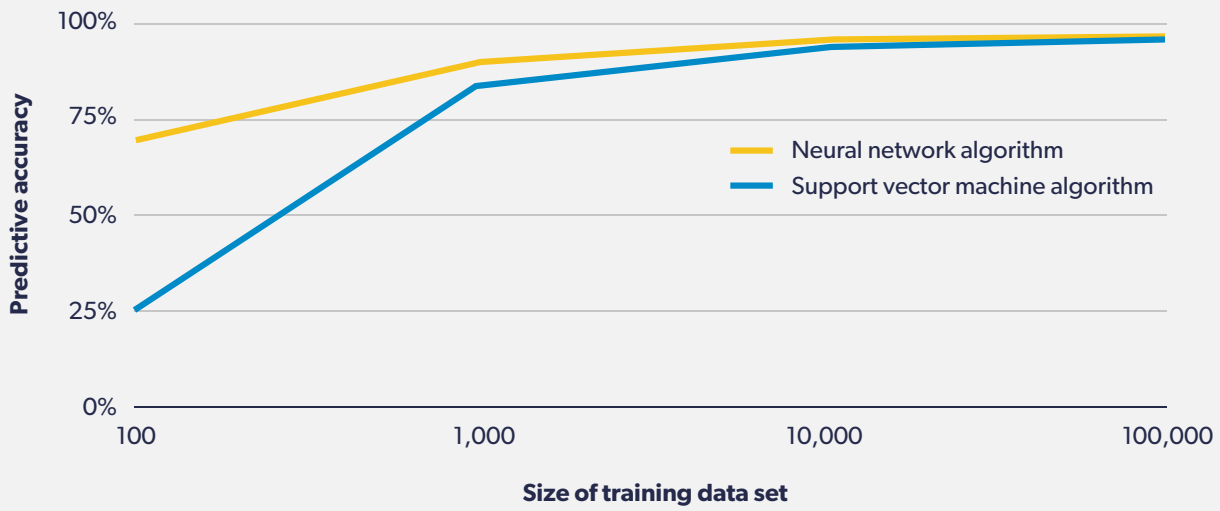
Initially the results of a machine learning algorithm will be poor. However, as larger volumes of training data are provided, the program's predictions can become highly accurate (fig. 5, overleaf).

**Fig. 4. The Evolution of AI: Machine learning**




Source: MMC Ventures

**Fig. 5. Large data sets enable effective machine learning**




Source: Michael Nielsen

Note: The size of data set required to train a machine learning algorithm is context dependent and cannot be generalised.

The defining characteristic of machine learning algorithms, therefore, is that the quality of their predictions improves with experience. The more data provided to a machine learning system, typically up to a point, the more effective its predictions. By learning through practice, instead of following sets of rules, machine learning systems can deliver better results than rules-based systems in numerous prediction and optimisation challenges.

## There are multiple approaches to machine learning

There are more than 15 approaches to machine learning. Each uses different types of algorithmic architecture to optimise predictions based on input data.

One, deep learning, is delivering breakthrough results in new domains. We explain deep learning below. Others receive less attention, but are widely used given their utility and applicability to a broad range of use cases. Popular machine learning algorithms beyond deep learning include:

- **Random forests** that create multitudes of decision trees to optimise predictions;
- **Bayesian networks** that use probabilistic approaches to analyse variables and the relationships between them;
- **Support vector machines** that are fed categorised examples and create models to assign new inputs to one of the categories.

Each approach offers advantages and disadvantages. Frequently, combinations are used (an 'ensemble' approach). The nature of available data frequently determines the algorithms selected. In practice, developers experiment to determine what is effective.

Machine learning can be applied to a wide variety of prediction and optimisation challenges. Examples include determining the probability that a credit card transaction is fraudulent, identifying products a person is likely to buy based on their prior purchases, and predicting when an industrial asset is likely to experience mechanical failure. We describe the applications of machine learning in multiple sectors in Chapter 4.

**The defining characteristic of machine learning algorithms is that the quality of their predictions improves with experience.**

## Deep learning: offloading feature specification

Even with the power of general machine learning, it is difficult to develop programs that perform certain tasks well, from understanding speech to recognising objects in images.

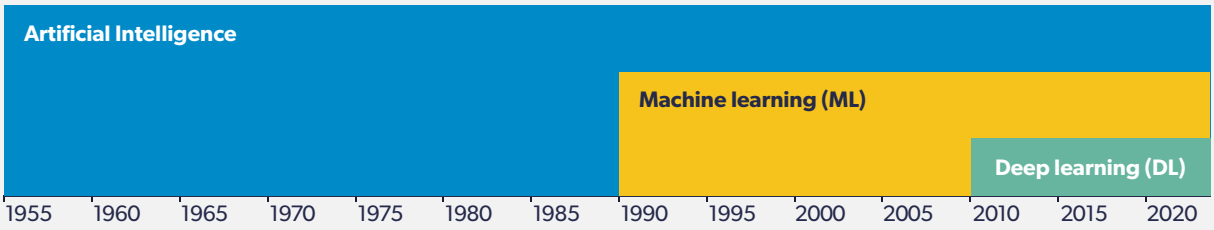
In these cases, programmers cannot specify the features in the input data to optimise. For example, it is difficult to write a program that identifies images of dogs. Variation in dogs' visual features is too broad to be described by a set of rules (fig. 6). We cannot list dogs' features in a way that will enable correct identification in all cases. Even if an exhaustive set of rules could be created, the approach would not be scalable. A new set of rules would be required for every type of object we wished to classify.

Deep learning is delivering breakthrough results in these use cases. Deep learning is a sub-set of machine learning and one of the many approaches to it (fig. 7). All deep learning is machine learning, but not all machine learning is deep learning.

**Fig. 6. Identifying features can be difficult ('Dalmatians or ice cream?')**

Source: Google Images

**Fig. 7. The Evolution of AI: Deep learning**

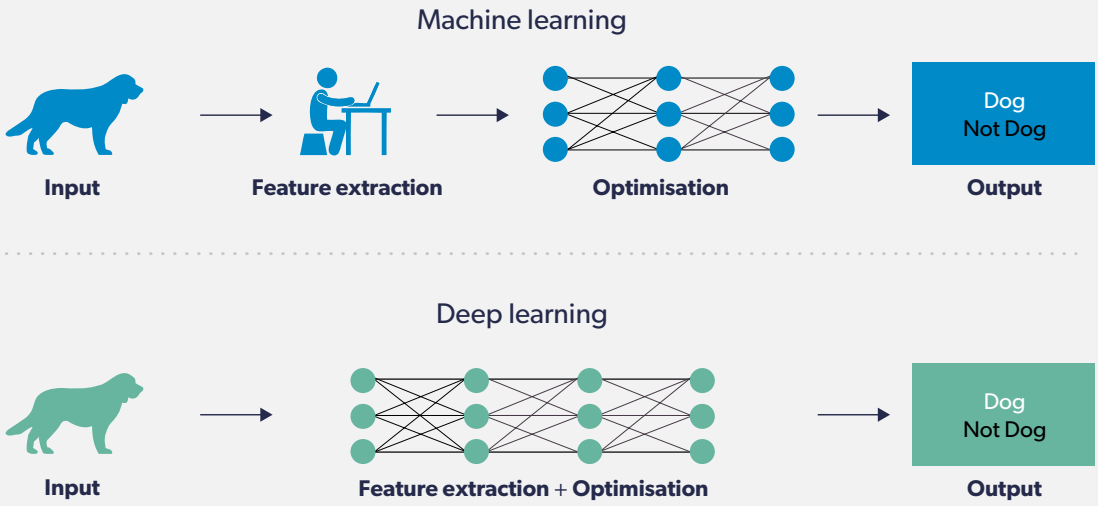



Source: MMC Ventures

**Even with the power of machine learning, it is difficult to develop programs that perform certain tasks well, from understanding speech to recognising objects in images.**

Deep learning is valuable because it transfers an additional burden – the process of feature extraction – from the programmer to their program (fig. 8).

**Fig. 8. Deep learning offloads the burden of feature extraction**




Source: MMC Ventures

**To undertake deep learning, developers create an artificial neural network that approximates the function of a brain.**

People learn to complete subtle tasks, such as recognising objects and understanding speech, not by following rules but through practice and feedback. As children, individuals experience the world (see a dog), make a prediction ("dog") and receive feedback. People learn by training. Deep learning works by recreating the mechanism of the brain (fig. 9, overleaf) in software (fig. 10, overleaf). With deep learning, we model the brain, not the world.

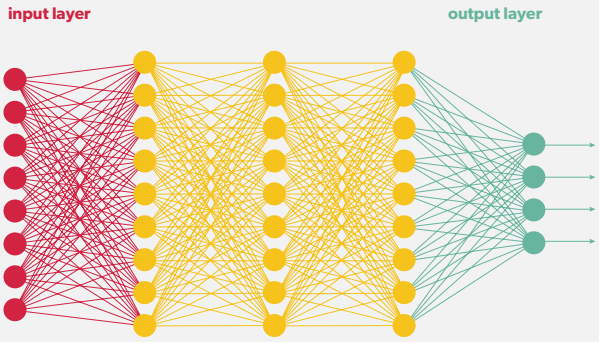
To undertake deep learning, developers create artificial neurons – software-based calculators that approximate the function of neurons in a brain. Artificial neurons are connected together to form a neural network. The network receives an input, such as a picture of a dog, extracts features, and makes a determination. If the output of the neural network is incorrect, the connections between the neurons adjust to alter its future predictions.

Initially the network's predictions will usually be incorrect. As the network is fed many – potentially millions – of examples in the domain, the connections between neurons become finely tuned. When analysing new examples, the artificial neural network will make correct determinations in almost all cases.

**Fig. 9. A biological neural network**

Source: iStock

**Fig. 10. An artificial neural network**




Source: MMC Ventures

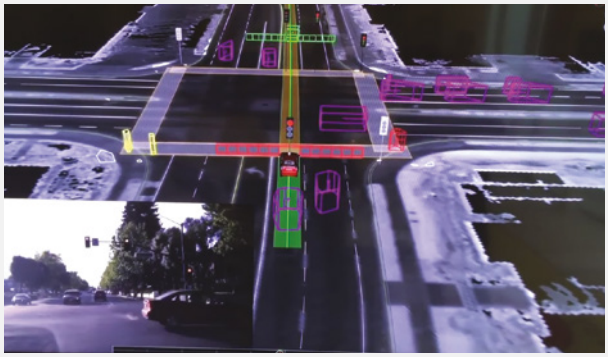
Deep learning has unlocked significant new capabilities, particularly in the fields of vision and language. Deep learning enables: autonomous vehicles to recognise objects in the world around them (fig. 11); the identification of tumours in medical images; the voice recognition systems of Apple and Google; voice-controlled devices such as Amazon Echo; real-time language translation (fig. 12); analysis of sentiment in text; and more.

Deep learning is not well suited to every problem. It typically requires large data sets for training. Extensive processing power is required to train and operate neural networks. Deep learning also suffers from an 'explainability' challenge – it can be difficult to know how a neural network developed its predictions.

By freeing programmers from the task of feature specification, however, deep learning has delivered successful prediction engines for a range of important use cases and is a powerful tool in the AI developer's arsenal.

**Deep learning has delivered successful prediction engines for a range of important use cases and is a powerful tool in the AI developer's arsenal.**

**Fig. 11. Deep learning enables autonomous vehicles to identify objects around them**



Source: Museum of Computer Science, MTV, CA

**Fig. 12. Google's Pixel Buds use deep learning to provide real-time language translation**

Source: Google / Pixel Buds

# How does deep learning work?

**An artificial neural network is created when artificial neurons are connected together. The output of one neuron becomes an input for another.**

Deep learning involves the creation of artificial neural networks – software-based calculating units (artificial neurons) that are connected.

An artificial neuron (fig. 13) has one or more inputs. The neuron performs a mathematical function on its inputs to deliver an output. The output will depend on the weights given to each input, and the configuration of the input-output function in the neuron. The input-output function can vary. An artificial neuron may be a:

- **linear unit** (the output is proportional to the total weighted input);
- **threshold unit** (the output is set to one of two levels, depending on whether the total input is above a specified value);
- **sigmoid unit** (the output varies continuously, but not linearly as the input changes).

An artificial neural network (fig. 14) is created when artificial neurons are connected to one another. The output of one neuron becomes an input for another.

**Fig. 13.**

**An artificial neuron**

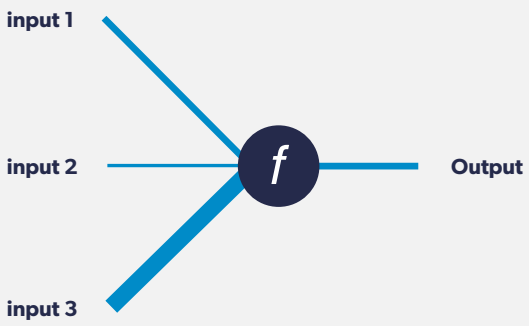
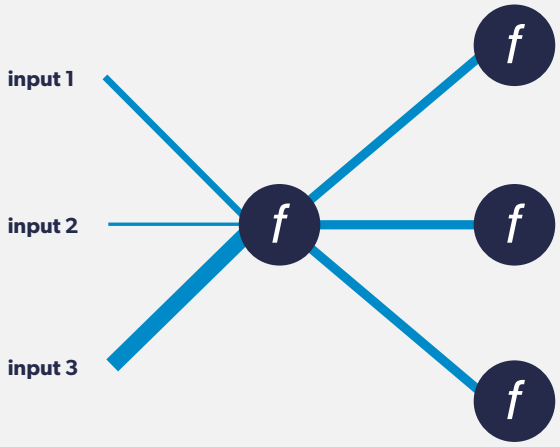



**Fig. 14.**

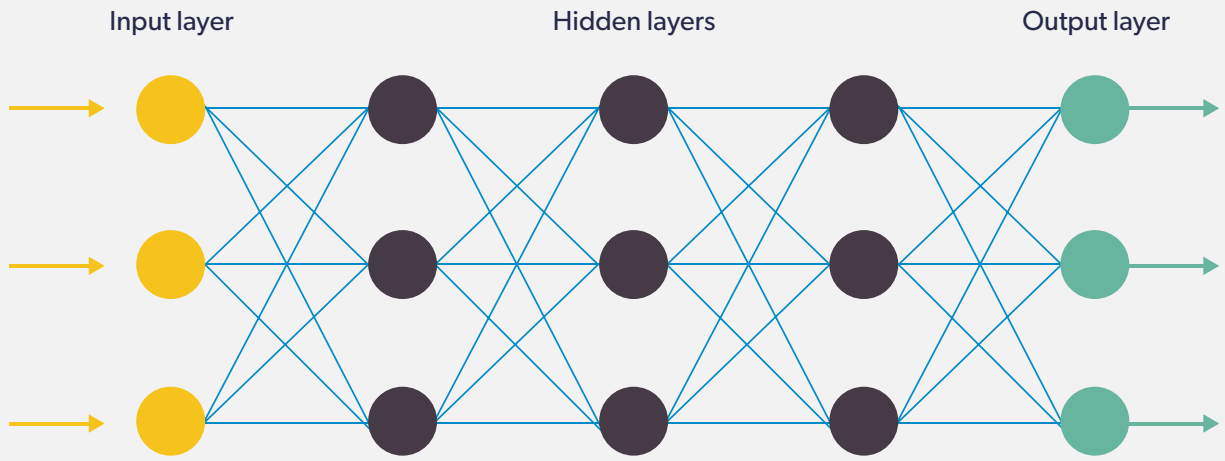
**An artificial neural network**




Source: MMC Ventures

## How does deep learning work?

**Fig. 15. Deep learning: structuring an artificial neural network**




Source: MMC Ventures

Neural networks are organised into multiple layers of neurons (fig. 15) – hence 'deep' learning. An input layer receives information to be processed, such as a set of pictures. An output layer delivers results. Between the input and output layers are hidden layers, where features are detected. Typically, the outputs of neurons on one level of a network all serve as inputs to each neuron in the next layer.

We can consider the example of a neural network designed to recognise pictures of human faces (fig. 16 overleaf). When pictures are fed into the neural network, the first hidden layers identify patterns of local contrast – low level features such as edges. As images traverse the hidden layers, progressively higher level features, such as shapes and objects, are identified. At its output layer, based on its training the neural network will deliver a probability that the picture is of a human face.

## How does deep learning work?

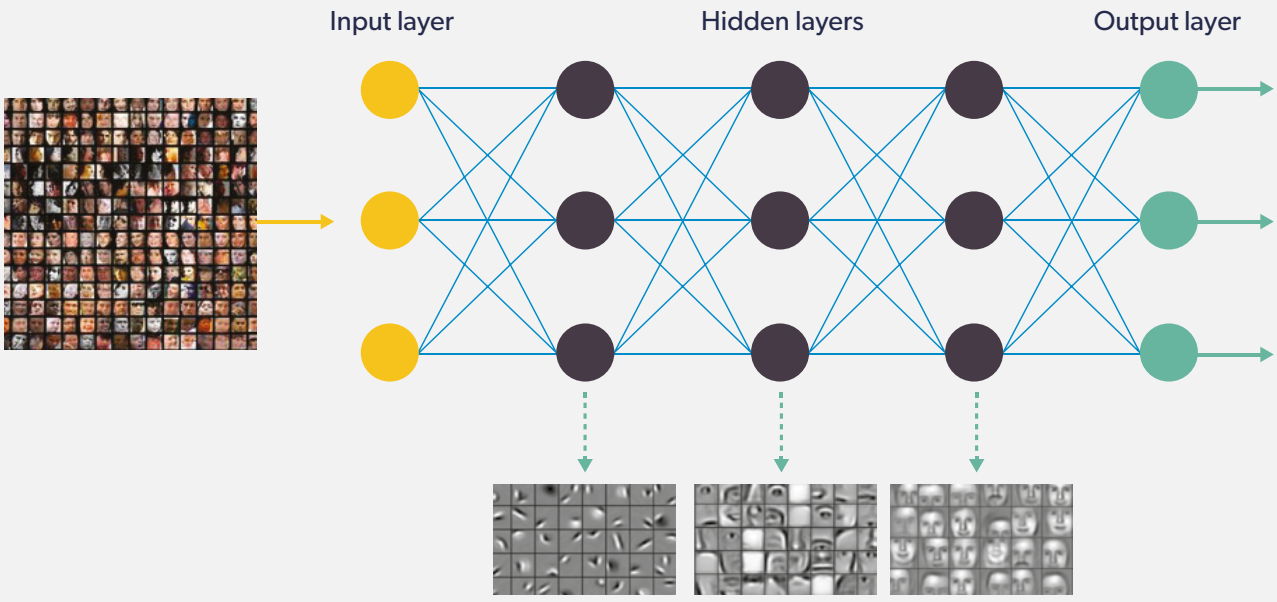
Typically, neural networks are trained through exposure to a large number of labelled examples. Errors are detected and the weights of the neurons' connections adjust to improve results. After the optimisation process is repeated extensively, the system is deployed to assess unlabelled images.

The neural network above is simple (and simplified), but structures can vary and most are more complex. Architectural variations include: connecting neurons on the same layer; differing the number of neurons per layer; and connecting neurons' outputs into previous layers in the network (recursive neural networks).

Designing and improving a neural network requires considerable skill. Steps include structuring the network for a particular application, providing suitable training data, adjusting the structure of the network according to progress and combining multiple approaches to optimise results.

**Typically, neural networks are trained through exposure to a large number of labelled examples. Errors are detected and the weights of the neurons' connections adjust to improve results.**

**Fig. 16. Deep learning: the process of feature extraction**




Source: MMC Ventures, Andrew Ng

# Chapter 2

# Why is AI important?

## Summary

- AI technology is important because increasingly, it enables human capabilities – understanding, reasoning, planning, communication and perception – to be undertaken by software effectively, efficiently and at low cost.
- General analytical tasks, including finding patterns in data, that have been performed by software for many years can also be performed more effectively using AI.
- The automation of these abilities creates new opportunities in most business sectors and consumer applications.
- Significant new products, services and capabilities enabled by AI include autonomous vehicles, automated medical diagnosis, voice input for human-computer interaction, intelligent agents, automated data synthesis and enhanced decision-making.

# Recommendations

## Executives

- Explore the new possibilities enabled by AI, from voice control and intelligent agents to autonomous vehicles and automated diagnosis, to appreciate the importance AI will have in the decade ahead.
- Familiarise yourself with the five fields of AI research we describe. Identify core aspects of your company's value proposition – for example, planning or communication – to which AI could be relevant.
- The new possibilities enabled by AI will have secondary consequences. Read Chapter 5 to understand the implications of AI.

## Entrepreneurs

- Explore opportunities, within your own organisation and for customers, to apply progress in the five fields of AI research we describe to solve intractable problems and ease difficult ones.
- Given the importance AI will have in the decade ahead, explore best practices for developing an AI capability (Chapter 9)

## Investors

- Recognise that although AI is hyped, the possibilities it enables are significant. 'Amara's law' is likely to apply – while we tend to overestimate the effect of a technology in the short term, we underestimate its effect in the long term.
- Given the importance of AI, assess the extent to which existing portfolio companies and new prospects are aware of AI and plan to take advantage of the technology.
- Seek companies that are using AI to fulfil new possibilities. The paradigm shift to AI will create large new winners.

## AI tackles profound technical challenges

AI is significant because it successfully tackles a profound set of technical challenges. Increasingly, human capabilities – understanding, reasoning, planning, communication and perception – can be undertaken by software, at scale and at low cost. General analytical tasks, including finding patterns in data, that have been performed by software for many years can also be performed more effectively using AI.

Together, these capabilities create new opportunities in most business processes and consumer applications.

## AI research is focused on five fields

Since its inception in the 1950s, AI research has focused on five fields of enquiry:

**1. Knowledge: The ability to represent knowledge about the world.**
For software to possess knowledge, it must understand that: certain entities, facts and situations exist in the world; these entities have properties (including relationships to one another); and these entities and properties can be categorised.

**2. Reasoning: The ability to solve problems through logical reasoning.**
Reasoning is the application of logic to derive beliefs, related ideas and conclusions from information. Reasoning may be deductive (specific conclusions are derived from general premises believed to be true), inductive (general conclusions are inferred from specific premises) or abductive (the simplest and most likely explanation for an observation is sought).

**3. Planning: The ability to set and achieve goals.**
For software to be able to plan, it must be capable of specifying an alternative, future state of the world that is desirable, together with a sequence of actions to that will effect progress towards it.

**4. Communication: The ability to understand written and spoken language.**
To communicate with people, software must have the ability to identify, understand and synthesise written or spoken human language.

**5. Perception: The ability to make deductions about the world based on sensory input.**
To perceive, software must be able to organise, identify and interpret visual images, sounds and other sensory inputs.

**Traditionally human capabilities – understanding, reasoning, planning, communication and perception – can be undertaken by software, at scale and at low cost.**

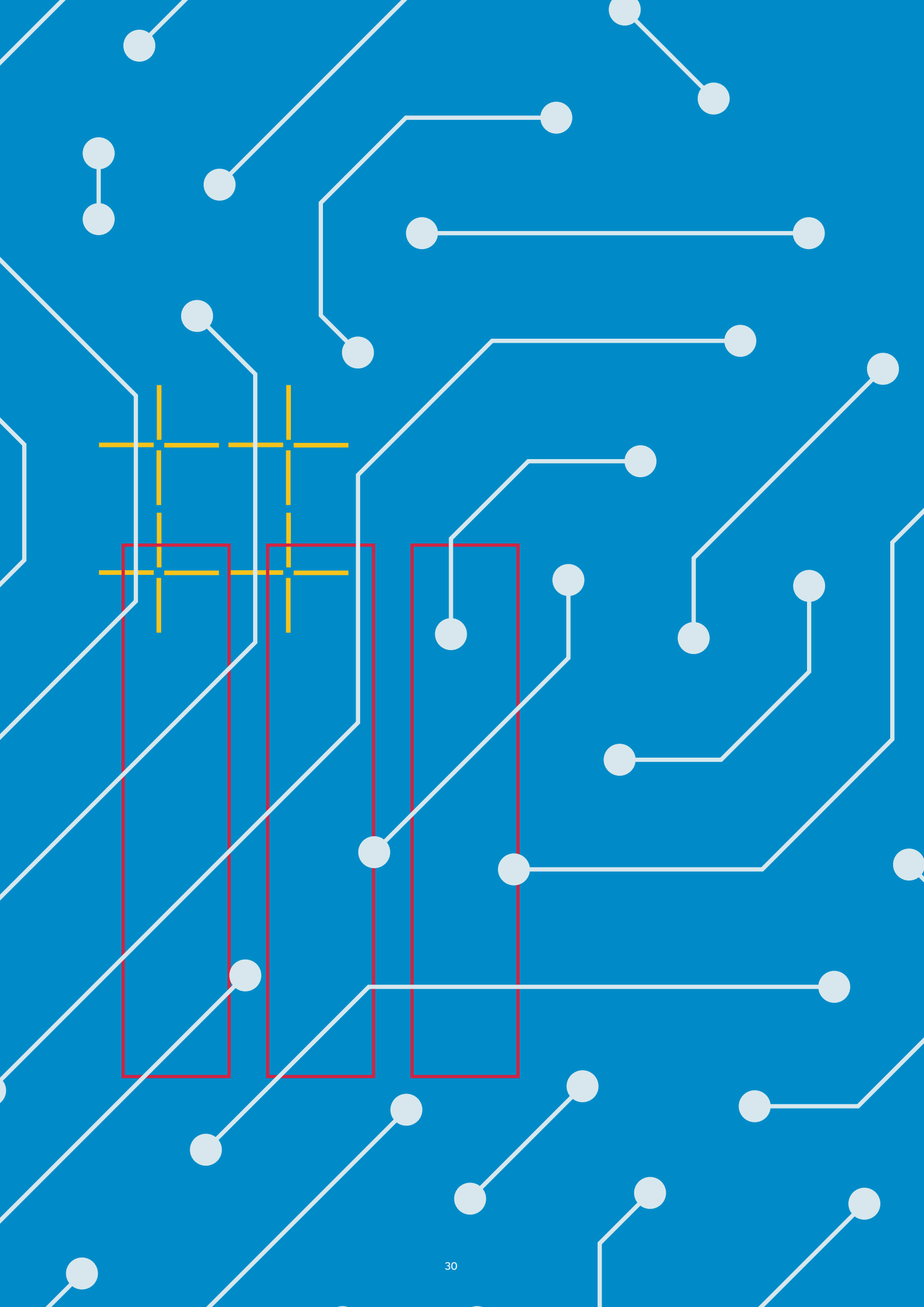
## Progress in AI unlocks new possibilities

Because most business processes and consumer applications involve aspects of knowledge management, reasoning, planning, communication or perception, progress in AI has unlocked significant new capabilities.

| New or improved possibilities | | | |
|---|---|---|---|
| **Knowledge** | Medical diagnosis | Drug creation | Media recommendation |
| | Financial trading | Information synthesis | Consumer targeting |
| **Reasoning** | Legal analysis | Asset management | Application processing |
| | Games | Autonomous weapons | Compliance |
| **Planning** | Logistics | Fleet management | Navigation |
| | Network optimisation | Predictive maintenance | Demand forecasting |
| **Communication** | Voice control | Intelligent agents | Customer support |
| | Real-time transcription | Real-time translation | Client service |
| **Perception** | Autonomous vehicles | Medical imaging | Authentication |
| | Augmented reality | Surveillance | Industrial analysis |

Source: MMC Ventures

In the following chapter, we describe specific AI use cases in eight sectors.



# Chapter 3

# Why is AI coming of age today?

## Summary

- After seven false dawns since its inception in 1956, AI technology has come of age.
- The capabilities of AI systems have reached a tipping point due to the confluence of seven factors: new algorithms; the availability of training data; specialised hardware; cloud AI services; open source software resources; greater investment; and increased interest.
- Together, these developments have transformed results while slashing the difficulty, time and cost of developing and deploying AI.
- A virtuous cycle has developed. Progress in AI is attracting investment, entrepreneurship and interest. These, in turn, are accelerating progress.

# Recommendations

## Executives

- Be aware that AI technology has come of age and will be a key enabler, and potential threat, in the coming decade.
- Familiarise yourself with the seven enablers of AI, the applications of AI (Chapter 4), and the implications of AI (Chapter 5) to lead and contribute to AI initiatives in your organisation.

## Entrepreneurs

- AI technology can deliver tangible benefits today. Look for opportunities to incorporate AI within your software, where appropriate, whether or not you are an 'AI company'.
- Explore AI infrastructure and services available from Google, Amazon, IBM and Microsoft, as well as open source machine learning libraries. They enable experimentation with AI at speed and low cost.
- Market your use of AI to gain attention from buyers and investors. Remember, however, that buyers seek solutions to business problems (not technology as an end in itself) and investors will look beyond the hype to evaluate your claims.

## Investors

- AI will be a powerful tool for existing portfolio companies – and a threat. Evaluate whether portfolio companies are embracing AI as a means of competitive advantage.
- With AI technology at a tipping point, seek opportunities to invest directly or indirectly in companies taking advantage of AI.
- Familiarise yourself with our AI Investment Framework (Chapter 10) for factors to consider when evaluating applied AI companies.

## There are seven enablers of AI

**Research into AI began in 1956. After seven false dawns, in which results from unsophisticated systems fell short of expectations, AI capability has reached a tipping point. AI is now delivering significant utility and its abilities are advancing rapidly.**

AI capabilities have been transformed in the last 48 months due to:

1. the development of more effective AI **algorithms**;
2. increased availability of **data** to train AI systems;
3. specialised **hardware** to accelerate training of AI algorithms;
4. cloud-based AI **services** to catalyse developer adoption;
5. **open source** AI software frameworks that enable experimentation;
6. increased **investment** in AI by large technology companies and venture capitalists;
7. greater **awareness** of AI among investors, executives, entrepreneurs and the public.

Together, these developments have improved results from AI systems and increased the breadth of challenges to which they can be applied. They have also irreversibly reduced the difficulty, time and cost of developing basic AI systems.

### 1. Enhanced algorithms have improved results

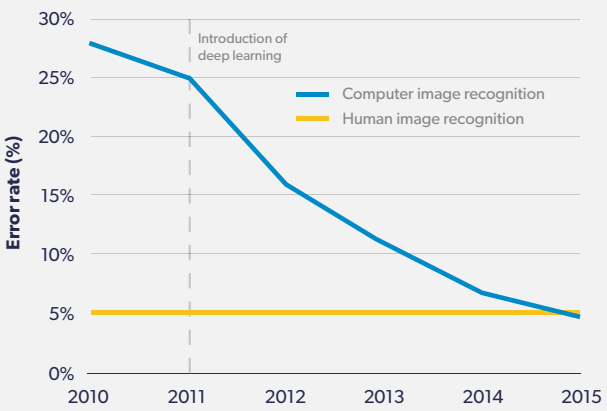
Deep learning, a fruitful form of machine learning, is not new; the first specification for an effective, multi-layer neural network was published in 1965. In the last decade, however, evolutions in the design of deep learning algorithms have transformed results, delivering breakthrough applications in areas including computer vision (fig. 17) and language (fig. 18).

**Convolutional Neural Networks (CNNs)** have dramatically improved computers' ability to recognise objects in images. Employing a design inspired by the visual cortexes of animals, each layer in a CNN acts as a filter for the presence of a specific pattern. In 2015, Microsoft's CNN-based computer vision system identified objects in pictures more effectively (95.1% accuracy) than humans (94.9% accuracy) (Microsoft). "To our knowledge," they wrote, "our result is the first to surpass human level performance." Broader applications of CNNs include video classification and speech recognition.

**Recurrent Neural Networks (RNNs)** are delivering improved results in speech recognition and beyond. While data progresses in a single direction in conventional ('feed forward') neural networks, RNNs have feedback connections that enable data to flow in a loop. With additional connections and memory cells, RNNs 'remember' data processed thousands of steps ago and use it to inform their analysis of what follows. This is valuable for speech recognition, where interpretation of an additional word is enhanced by analysis of preceding ones.

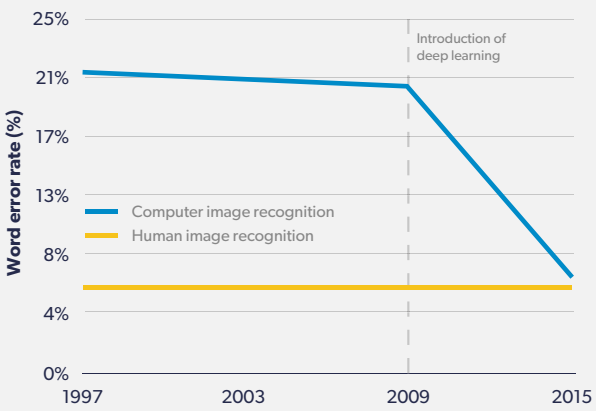
The Long Short-Term Memory (LSTM) model is a particularly effective new RNN architecture. From 2012, Google used LSTMs to power speech recognition in the Android platform. In October 2016, Microsoft reported that its LSTM speech recognition system achieved a word error rate of 5.9% – human-level speech recognition for the first time in history (Microsoft). By August 2017, word error rate had been reduced to 5.1% (Microsoft).

**Fig. 17. Human-level image recognition**




Source: MMC Ventures, Microsoft

**Fig. 18. Human-level speech recognition**




Source: MMC Ventures, Microsoft

### 2. Extensive data has enabled training of AI systems

Large data sets – thousands or millions of examples, depending on the domain – are typically required to train a neural network. The creation, and availability, of data have grown exponentially in recent years, fuelling AI.

Today, humanity produces 2.5 exabytes (2,500 million gigabytes) of data daily (Google). 90% of all data has been created in the last 24 months (Sintef ICT). Data has ballooned as humanity passed through two waves of data creation, and now enters a third.

The first wave of data, which began in the 1980s, involved the creation of documents and transactional data. It was catalysed in the 1990s by the proliferation of internet-connected desktop PCs. A second wave of data followed, with an explosion of unstructured media (emails, photos, music and videos), web data and meta data from pervasive, connected smartphones.

Today we enter the third age of data. Machine sensors deployed in industry and the home provide additional monitoring-, analytical- and meta-data.

With much data created today transmitted for use via the internet, growing internet traffic is a proxy for humanity's increasing data production. In 1992, humanity transferred 100GB of data per day. By 2020, we will transfer 61,000GB per second (fig.19) (Cisco, MMC Ventures).

Specialist data resources have further catalysed the development of AI. ImageNet, a free database of 14.2 million hand-labelled images, has supported the rapid development of deep learning algorithms used to classify objects in images.

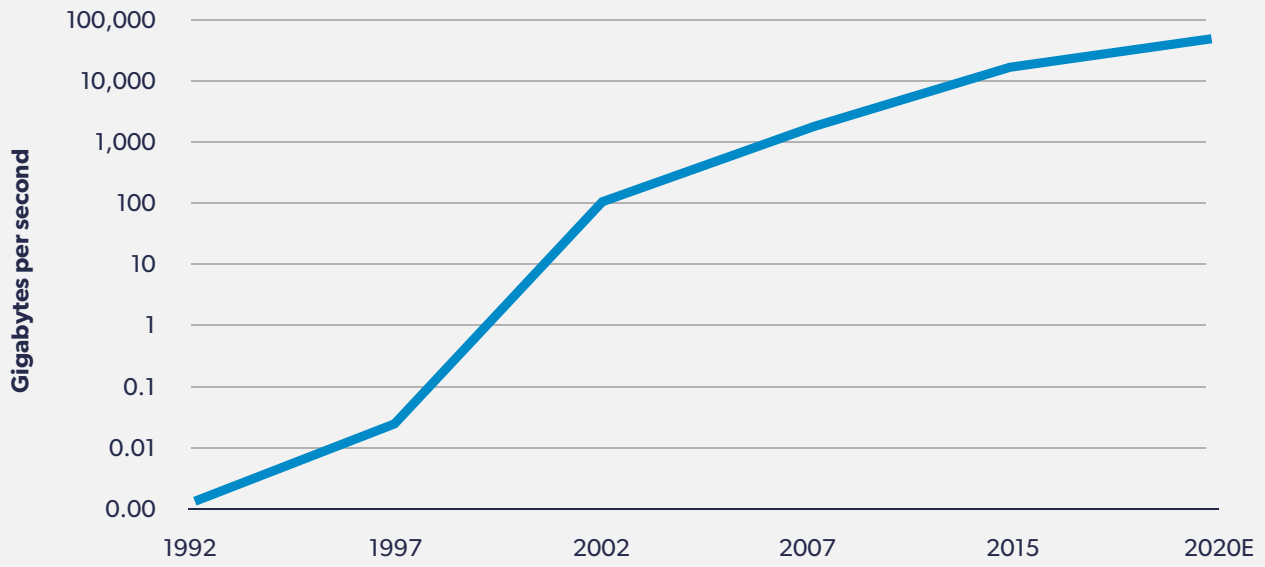
### 3. Specialised hardware has accelerated training of AI systems

Graphical Processing Units (GPUs) are specialised electronic circuits that slash the time required to train the neural networks used in deep learning-based AI.

Modern GPUs were developed in the 1990s, to accelerate 3D gaming and 3D development applications. Panning or zooming a camera in a simulated 3D environment uses a mathematical process called a matrix computation.

Microprocessors with serial architectures, including the Central Processing Units (CPUs) that interpret and execute commands in today's computers, are poorly suited to the task. GPUs were

**Fig. 19. Global internet traffic is increasing exponentially**




Source: Cisco, MMC Ventures

developed with massively parallel architectures (Nvidia's M40 GPU has 3,072 cores) to perform matrix calculations efficiently.

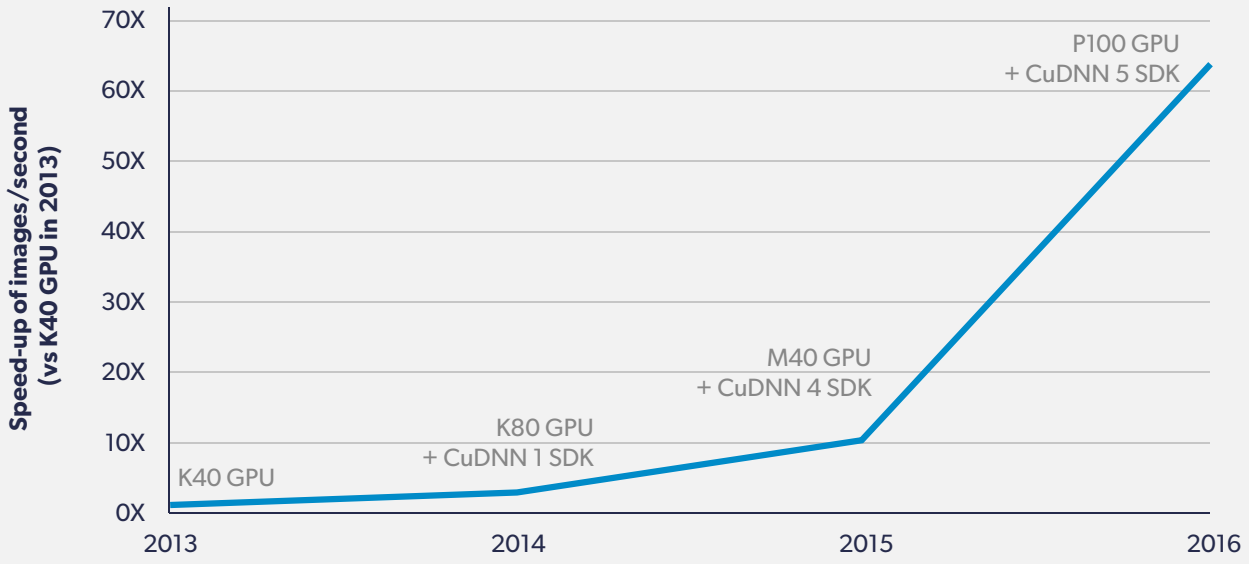
Training a neural network involves numerous matrix computations. GPUs, while conceived for 3D gaming, therefore proved ideal for accelerating deep learning. Their effect is considerable. A simple GPU can increase five-fold the speed at which a neural network can be trained. Ten-fold or larger gains are possible. When combined with Software Development Kits (SDKs) tuned for popular deep learning frameworks, improvements in training speed can be even greater (fig. 20).

**61,000**

Gigabytes per second will be transferred by humanity, by the year 2020.

Source: Cisco, MMC Ventures

**Fig. 20. 60x neural network training speed in three years**




Source: NVIDIA, MMC Ventures

**4. Cloud AI services have fuelled adoption**

Developers' adoption of a technology supports its proliferation. Leading software providers including Google, Amazon, IBM and Microsoft have offered cloud-based AI infrastructure and services, enabling developers' use of AI.

The providers' infrastructure platforms include environments in which to build and iterate AI algorithms, and 'GPUs-as-a-service' to power them. Their services comprise a burgeoning range of on-demand AI capabilities, from image recognition to language translation, which developers can incorporate in their own applications.

Google machine learning offers APIs for: computer vision (object identification, explicit content detection, face recognition and image sentiment analysis); speech (speech recognition and speech-to-text); text analysis (entity recognition, sentiment analysis, language detection and translation); and employee job search (opportunity surfacing and matching). Microsoft Cognitive Services include over 21 services in the fields of vision, speech, language, knowledge and search. The accessibility and relative affordability of cloud providers' AI infrastructure and services are significantly increasing adoption of AI among developers.

**5. Open source software has catalysed experimentation**

The availability of open source AI software frameworks has lowered barriers to entry for experimentation and proficiency in AI.

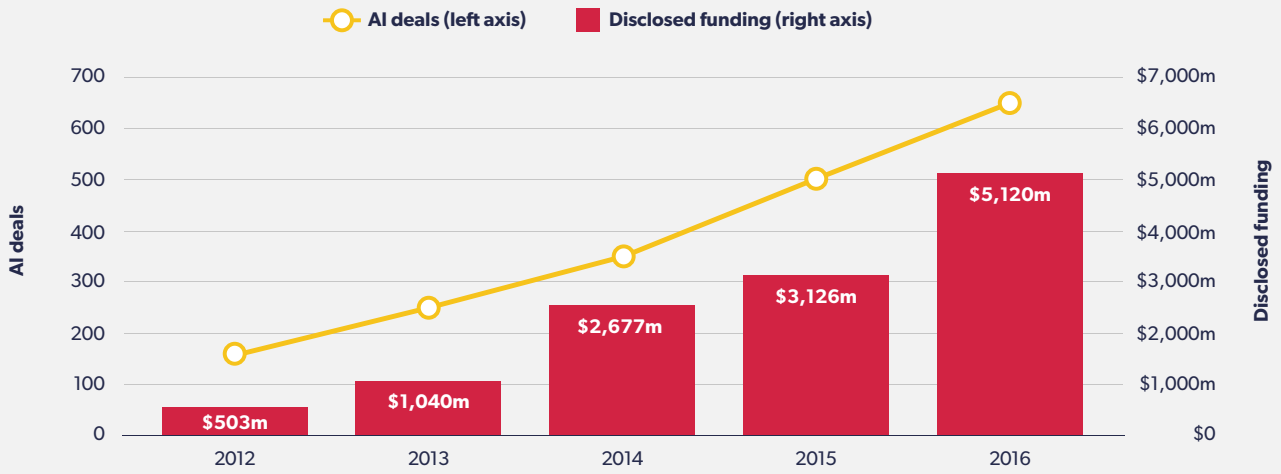
Researchers, and providers of cloud infrastructure and AI services, are open-sourcing AI frameworks and libraries of algorithms to catalyse developers' adoption of AI. (Infrastructure providers also benefit from the proliferation of data-intensive AI applications). Popular open source platforms include TensorFlow (Google), Caffe2 (Facebook), Cognitive Toolkit (Microsoft), TorchNet (Facebook), H2O (H2O.ai) and Mahout (Apache Software Foundation).

Each framework offers benefits. Caffe2 is a scalable deep learning framework that can process images at speed. Cognitive Toolkit provides high performance on varying hardware configurations. H2O reduces time-to-value for AI-powered enterprise data analysis. Mahout provides scalability and pre-made algorithms for tools such as H2O. Google's decision to open source TensorFlow in November 2015 was particularly significant, given the software's sophistication.

**6. Investment in AI has increased ten-fold**

Given opportunities for value creation, venture capital firms are investing aggressively in AI. Investment dollars into early stage AI companies globally have increased ten-fold in four years (fig. 21), to over $5B in 2016 (CB Insights). Today's leading technology companies – including Apple, Amazon, Facebook, Google, IBM, Microsoft and Salesforce – are also spending heavily on research and personnel to develop and deploy AI.

**Fig. 21. Venture capital investment in AI has increased ten-fold**




Source: CB Insights

**Investment dollars into early stage AI companies globally have increased ten-fold in four years, to over $5bn in 2016.**

**CB Insights**

### 7. Awareness of AI has grown significantly

Public interest in AI, measured by the proportion of Google searches for 'machine learning', has increased six-fold in five years (fig. 22).

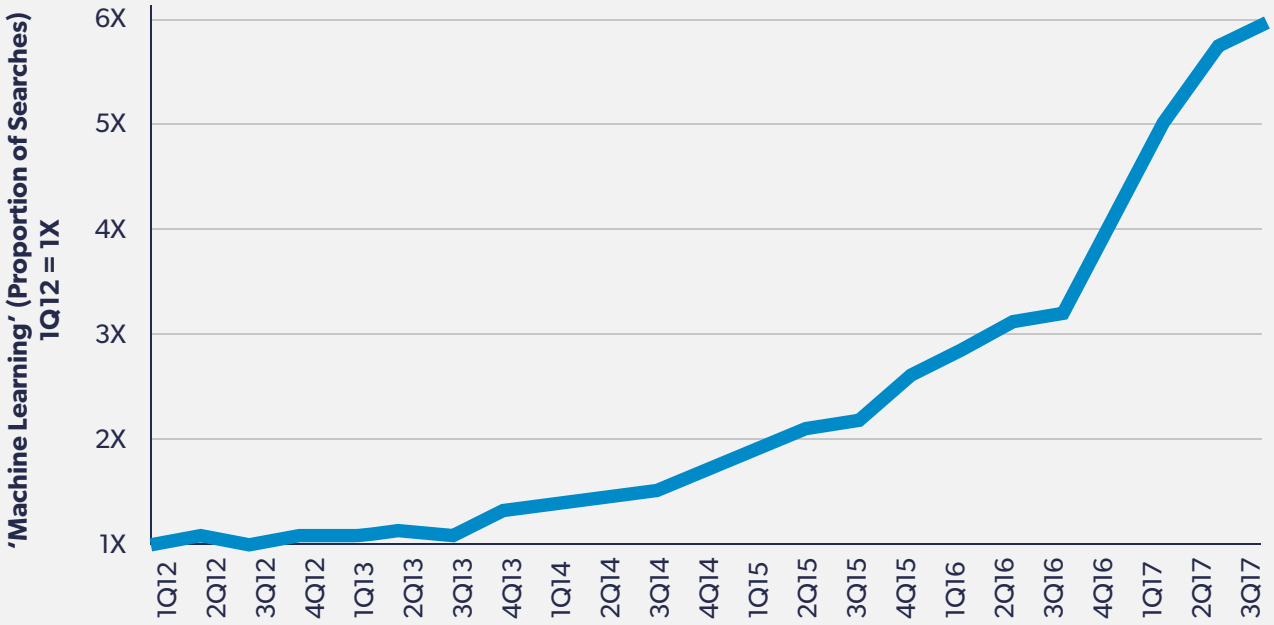
Executives' awareness of AI has grown following extensive coverage in business publications. In just the last 12 months, 6,600 articles referencing AI have appeared in Bloomberg Businessweek, the Financial Times, Forbes, Fortune, the Harvard Business Review and The Wall Street Journal (Signal Media). One third of these references have appeared in the last 12 weeks.

In the popular press, whether relevant (the opportunities and threats posed by automation) or less so ('killer robots'), over 19,000 articles in US and UK newspapers have referred to AI, fuelling public interest (Signal Media).

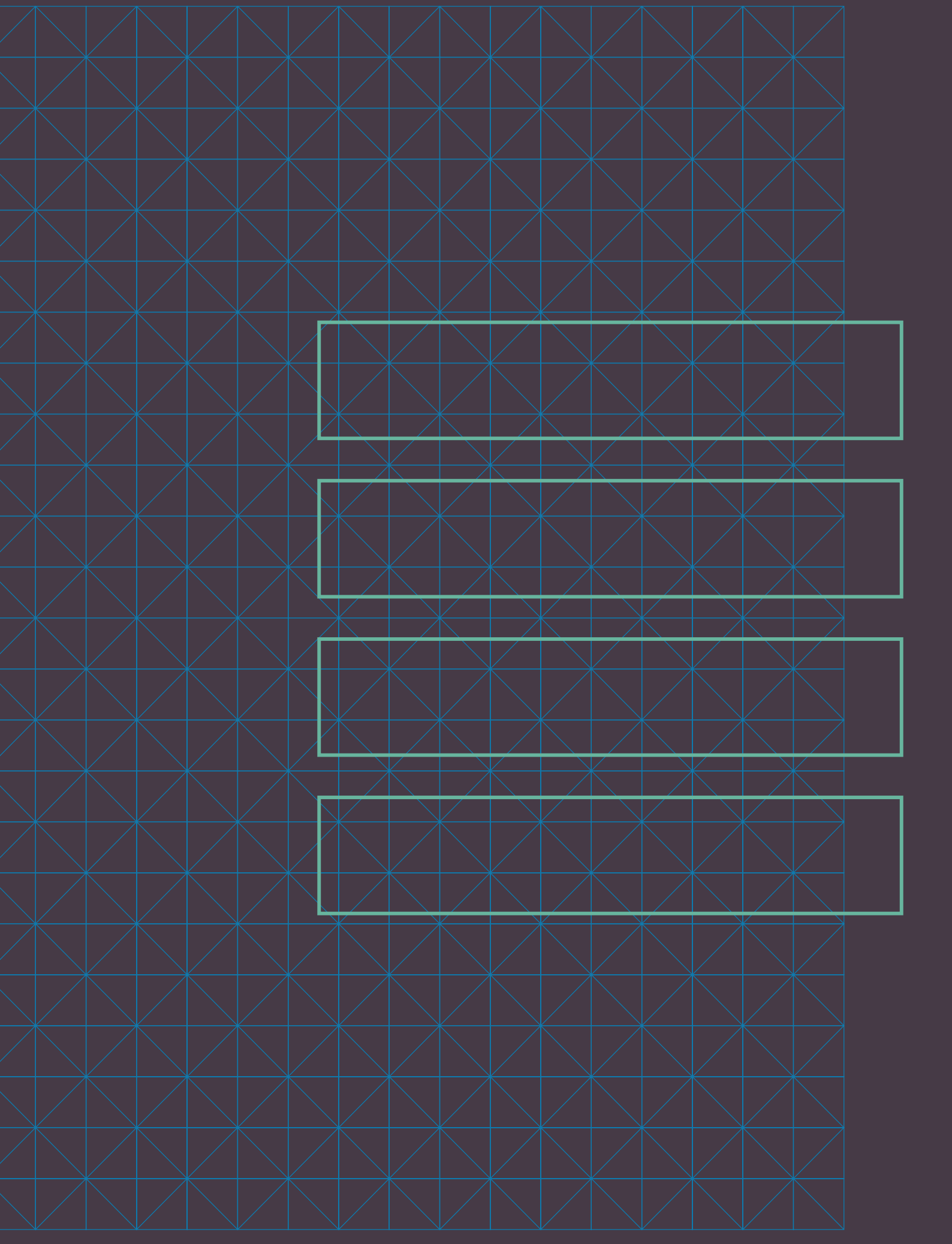
**In just the last 12 months, 6,600 articles referencing AI have appeared in Bloomberg Businessweek, the Financial Times, Forbes, Fortune, the Harvard Business Review and The Wall Street Journal.**

**Signal Media**

**Fig. 22. Interest in AI has increased 6-fold**




Source: Google Trends



# Chapter 4

# The applications of AI

## Summary

- AI has numerous, tangible use cases today that are enabling corporate revenue growth and cost savings.
- The capabilities of AI – its power to incorporate broader data sets into analyses, identify concepts and patterns in data more effectively, and enable human-to-machine conversation – will have application in all sectors and numerous business processes.
- Applications will be most numerous in sectors in which a large proportion of time is spent collecting and synthesising data: financial services, retail and trade, professional services, manufacturing and healthcare. Applications of AI-powered computer vision will be particularly significant in the transport sector.
- Use cases are proliferating as AI's potential is understood. We describe 31 core use cases across eight sectors: asset management, healthcare, insurance, law & compliance, manufacturing, retail, transport and utilities.
- We illustrate how AI can be applied to multiple processes within a business function (human resources).

# Recommendations

## Executives

- Explore the breadth of AI use cases to understand the impact AI will have in the next five years.
- Examine AI use cases in a range of sectors to familiarise yourself with the technical capabilities of AI – from incorporating additional data sets into analyses to identifying patterns in data more effectively and understanding written and spoken language.
- Assess the extent to which time is spent collating and processing data in your industry. AI's impact will be greatest in sectors where data synthesis and processing are core.
- Identify business processes in your sector that could be improved, automated or reinvented using AI.

## Entrepreneurs

- AI offers new opportunities for disruption in sectors ranging from manufacturing to healthcare. Identify business processes ripe for improvement or reinvention through AI, particularly in sectors in which data synthesis or processing are extensive.
- Customers buy solutions, not technology. If establishing a B2B AI company, focus on a clear sector use case or business process and articulate a compelling ROI for business buyers.
- AI has numerous capabilities, from multi-variate analysis to natural language processing. As appropriate, identify opportunities to use multiple aspects of AI, both within your company and for buyers.
- Familiarise yourself with early stage competitors in your sector (see Chapter 8) and monitor their focus, approach and capabilities.

## Investors

- Evaluate opportunities and threats to existing portfolio companies from the many applications of AI.
- In sectors you favour, evaluate business processes most and least at risk of change through AI.
- Leverage domain expertise when evaluating opportunities to invest in AI opportunities. Sector dynamics are likely to be as, or more, important drivers of early stage companies' success than technological capability.
- With AI poised to impact multiple sectors, develop a framework to identify preferred sectors for investment. Considerations are likely to include fundamentals (scope for structural change in a sector due to AI) and pragmatic factors (sector expertise).

## The applications of AI are numerous and tangible

AI is not a set of solutions looking for a problem; it is a set of capabilities unlocking revenue growth and cost savings today.

The capabilities of AI – its power to incorporate broader data sets into analyses, identify concepts and patterns in data more effectively than rules-based systems, and enable human-to-machine conversation – have applications in all sectors and numerous business processes. In about 60% of occupations, at least 30% of constituent activities are technically automatable by adapting currently proven AI technologies. (McKinsey Global Institute). As such, AI is a key 'enabling technology'.

**In about 60% of occupations, at least 30% of constituent activities are technically automatable by adapting currently proven AI technologies.**

**McKinsey Global Institute**

## Data-centric sectors will see the greatest impact

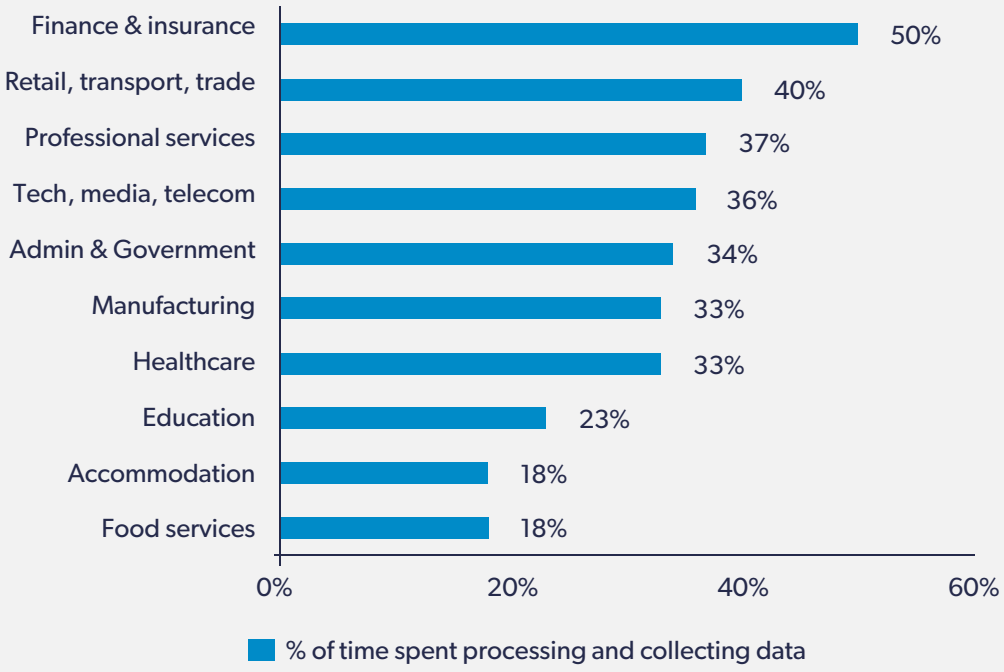
In the next ten years, AI will be deployed in all sectors and to a wide variety of business processes. However, AI will have more numerous applications and greater impact in some sectors than others.

AI's impact will be greatest in sectors in which a large proportion of time is spent collecting or synthesising data, or undertaking predictable physical work. In several sectors (fig. 23), professionals spend one third or more of their time on the above (McKinsey, Julius Baer). These sectors include:

**Finance and insurance** (50% of time)
**Retail, transport and trade** (40% of time)
**Professional services** (37% of time)
**Manufacturing** (33% of time)
**Healthcare** (33% of time)

Applications will be more limited in sectors where data synthesis and processing activities are limited, or where the majority of people's time is spent managing others, applying expertise, or undertaking unpredictable physical work. Occupations such as management and teaching will be more resilient to AI in the medium term.

**Fig. 23. Share of time spent collating and processing data**




Source: McKinsey, Julius Baer

## Core use cases vary by sector

Use cases for AI are proliferating as understanding of the technology improves. We describe 31 core AI use cases in eight sectors: asset management, healthcare, insurance, law & compliance, manufacturing, retail, transport and utilities.

| Sector | Core use cases: | | | |
|---|---|---|---|---|
| **Asset Management** | Investment strategy | Portfolio construction | Risk management | Client service |
| **Healthcare** | Diagnostics | Drug discovery | Monitoring | |
| **Insurance** | Risk assessment | Claims processing | Fraud detection | Customer service |
| **Law & compliance** | Case law | Discovery and due diligence | Litigation strategy | Compliance |
| **Manufacturing** | Predictive maintenance | Asset performance | Utility optimisation | |
| **Retail** | Customer segmentation | Content personalisation | Price optimisation | Churn prediction |
| **Transport** | Autonomous vehicles | Infrastructure optimisation | Fleet management | Control applications |
| **Utilities** | Supply management | Demand optimisation | Security | Customer experience |

Source: MMC Ventures

## Asset management

**AI's ability to extract content from unstructured data using natural language processing, find subtle patterns in disparate data sets, and enable machine-to-human communication via chatbots, has multiple applications in asset management. Core use cases include investment strategy, portfolio construction, risk management and client service. By augmenting or automating many of an asset manager's tasks, AI enables asset managers to deliver to the mass affluent a degree of personalisation and service quality previously reserved for high net worth clients. Additionally, AI can decrease the cost of portfolio construction while improving quality – the era of the 'robo-advisor'.**

**Investment strategy:** AI can improve a firm's investment strategy by synthesising its research and data, and incorporating broader data sets including unstructured information. Superior pattern recognition can then deliver better multi-objective optimisation. AI can balance a diverse range of inter-connected objectives (including fund deployment, risk and profitability) to enhance returns more effectively than rules-based systems.

**Portfolio construction:** AI tools can augment, and increasingly automate, an asset manager's process of portfolio construction. AI – 'robo-advisors' – can analyse a client's goals, and within a firm's investment rules develop personalised, optimised portfolios at low cost and high speed.

**Risk management:** AI can improve risk management for the same reasons it enhances investment strategy: interpretation of broader data sets and improved cognitive processing. 90% of data generated today is unstructured information, stored outside traditional databases (International Data Group). Natural language processing enables additional data sets to be incorporated into firms' analyses. Other AI techniques, including deep learning, then enable patterns in data to be identified with greater granularity and confidence. Together, these capabilities enable risks to be identified and quantified more effectively.

**Client service:** Chatbot interfaces are being applied within and beyond asset management firms. Deployed in client-facing channels, natural language systems enable client enrolment, support and self-service. Embedded in internal tools, chatbots let account managers query client details and understand developments relevant to a client's portfolio in seconds instead of minutes. Fewer account managers can then provide a higher quality service to a greater number of clients.

**Early stage UK companies include:**

| | |
|---|---|
| **Risk Forecasting**<br>Algo Dynamix | **Sales Optimisation**<br>Arkera |
| **Advisory**<br>ForwardLane<br>Zenith One | **Valuation**<br>PriceHubble<br>Proportunity |

## Healthcare

In the next 20 years, AI can unlock a paradigm shift in healthcare to improve patient care and process efficiency. Automated diagnosis was an early use case for rudimentary AI in the 1980s. 'Expert systems' mimicked human approaches to diagnosis, applying rules-based inferences to bodies of knowledge. Modern AI, particularly deep learning, is more effective and applicable to a wider range of processes. Key use cases include diagnosis, drug discovery and patient monitoring.

**Diagnosis:** Replacing complex, human-coded sets of probabilistic rules, deep learning solutions identify subtle correlations between vast, multi-variate data sets to deliver scalable, automated diagnosis. While systems are nascent, accuracy is improving rapidly. Separately, computer vision solutions powered by deep learning are transforming diagnostic imaging. While human radiologists require extensive expertise and years of training to identify abnormalities in magnetic resonance images and ultrasounds, deep learning systems trained on large data sets deliver impressive results. In 2017, diagnostic imaging powered by deep learnings offers human-level accuracy and high speed in select contexts.

**Drug discovery:** Today's drug discovery process is lengthy, averaging 12 years to market (California Biomedical Research Association). Expense and uncertainty are also prohibitive; drug development costs an average of $359m and just 2% of US preclinical drugs are approved for human use (ibid). AI is being applied to multiple stages of the drug development process to accelerate time to market and reduce uncertainty. AI is being applied to synthesise information and offer hypotheses from the 10,000 research papers published daily, predict how compounds will behave from an earlier stage of the testing process, and identify patients for clinical trials.

**Monitoring:** Monitoring the vital signs of patients on non-acute wards, or at-risk individuals in the home, remains a manual process undertaken periodically. AI can synthesise signals from inexpensive wearable devices worn by patients to deliver clinical-grade monitoring, and enable a large group of patients to be monitored in real-time by a single nurse. As data sets are amalgamated and algorithms are tuned, AI will offer predictive analytics. Patients in a ward or at home who require further hospital care can be identified and supported, while unnecessary use of hospital beds can be reduced.

**Early stage UK companies include:**

| | |
|---|---|
| **Diagnostics/Information**<br>Aequa Science<br>Babylon Health<br>BrainWaveBank<br>Sime Diagnostics<br>Transformative<br>Your.MD | **Workflow Optimisation**<br>Clinithink<br>Deontics<br>Kaido<br>Kraydel<br>Optellum<br>Synthace<br>Visulytix |
| **Movement Diagnostics**<br>AIMO | **Mental Health**<br>Ieso Digital Health |
| **Diagnostic Imaging**<br>Avalon AI<br>Innersight Labs<br>Kheiron<br>ThinkSono<br>Viz | **Genomics**<br>Desktop Genetics<br>InsideDNA<br>PetaGene<br>Resurgo Genetics |
| **Surgical Robotics**<br>Cambridge Medical Robotics | **Drug Discovery**<br>Exscientia<br>HealX<br>LabGenius<br>BenevolentAI |
| **Healthcare IoT**<br>Drayson Technologies<br>Snap40 | |

## Insurance

While the fundamentals of insurance – customer prospecting, risk assessment, claims processing and fraud detection – have remained unchanged, modern AI can improve every stage in the insurance process to deliver efficiency savings and improved customer experience. By identifying patterns in data better than rules-based systems, AI can improve and accelerate decision-making and claims processing, reduce fraud and automate a large proportion of customer service enquiries.

**Risk assessment:** AI can gather information from broader data sets, including web and social media profiles, to compile richer customer information and inform risk assessment. AI can then assess the risk of individual policies more accurately than rules-based systems, by detecting non-linear patterns in multi-variate data sets and making projections.

**Claims processing:** AI can reduce time-to-quote, time-to-claim and claims processing costs for consumers and insurers. By analysing images of damaged assets, AI can automatically classify claims. Through improved pattern recognition applied to prior cases, AI can also predict settlement costs. Algorithms using deep learning are effective for image analysis, while Bayesian (probability-based) AI is useful for predicting settlement costs.

**Fraud detection:** Insurance fraud costs UK insurers £1.3B annually and ads £50 to the average policyholder's annual bill (Association of British Insurers). UK insurers invest over £200m annually to tackle the challenge (ibid). Fraud detection algorithms enhanced with AI can identify fraudulent transactions, while reducing false positives, more effectively than traditional rules-based or linear regression approaches.

**Customer service:** Chatbot interfaces integrated with insurers' databases can use natural language processing to offer 24/7 product information and answers to policyholders' enquiries in a scalable, inexpensive and personalised channel.

**Early stage UK AI companies include:**
Brolly, CoVi Analytics, Oseven, Spixii

## Law and Compliance

AI's abilities to process language in documents, synthesise knowledge and automate reasoning have broad application in the legal services and compliance sector. With junior lawyers spending a high proportion of their time accessing and collating information, scope for augmentation and automation is considerable. Key AI use cases include identifying relevant case law, processing documents for discovery and due diligence, and informing litigation strategy.

Regarding compliance, costs have grown significantly since 2008 – particularly for financial services firms. With rules-based software poorly suited to catching infractions, banks have invested in additional compliance personnel. Citi, while reducing its global headcount 32% between 2008 and 2016, doubled its regulatory and compliance staff to 29,000 – over 13% of it workforce (Citi). AI's ability to learn patterns of behaviour over time, and highlight unusual activity in real-time, offers greater scalability at lower cost.

**Case law, discovery and due diligence:** Natural language processing AI can identify, classify and utilise content from databases and unstructured documents at scale and speed, saving legal firms time and cost for routine document review. Use cases include sourcing and ranking relevant case law and identifying key documents in due diligence and discovery processes. With a merger and acquisition data room containing an average of 34,000 pages for review (Luminance), AI can increase business velocity and reduce costs.

**Litigation strategy:** AI can analyse past judgements at greater speed, granularity and subtlety than has been possible to date. By anticipating the probability of different outcomes, lawyers' strategic decision-making can be informed and enhanced. In high volume areas, such as personal injury, software can help a firm decide whether to accept a case. In high value areas, including corporate litigation, software can suggest the probability of a particular outcome based on juries' prior behaviour and opposing lawyers' tendency to settle or proceed to trial.

**Compliance:** Preventing accidental or deliberate breaches of policy, from the theft of sensitive data to accidentally misaddressing an email containing a customer database, is challenging for rules-based systems. By learning the habits of users over time, AI systems can flag potential compliance breaches in real-time, before they occur, with sufficient accuracy to enable broad deployment.

**Early stage UK companies include:**

| | |
|---|---|
| **Identity Verification**<br>AimBrain<br>Callsign<br>Eyn<br>iProov<br>Onfido<br>VChain Technology | **Data Anonymisation**<br>Anon AI<br><br>**Data Classification**<br>Exonar<br>Semantic Evolution |
| **Regulation Analytics**<br>ACognitiv+<br>CoVi Analytics<br>WaymarkTech | **Contract Analysis**<br>Eigen Technologies<br>Luminance<br>ThoughtRiver |
| **Email Security**<br>CheckRecipient | **Monitoring Optimisation**<br>Recordsure |

## Manufacturing

AI can significantly improve manufacturers' efficiency and profitability. Overall Equipment Effectiveness (OEE), a measure of manufacturers' productivity relative to potential, varies considerably by industry, from 75%-91% (LNS Research). The performance of companies within the same industry also vary widely, offering scope for competitive advantage. AI can boost OEE and profitability by predicting equipment failure (to reduce unplanned downtime), improving assets' operational efficiency, and reducing utility supply costs.

**Predictive maintenance:** Failure of production assets is costly; one hour of unplanned downtime on an automotive assembly line can cost a manufacturer £1.5m (MMC Ventures). AI can identify subtle patterns in data from vibration, temperature, pressure and other sensors to identify leading indicators of equipment failure. By predicting more accurately which components are likely to fail, and when, parts can be proactively replaced to prevent failures and save money.

**Asset performance:** AI can improve the operation of high value assets, including gas and wind turbines, to optimise yield. Rules-based programs deliver limited results when applied to complex tasks, such as tuning fuel valves on a gas turbine to optimise combustion while reducing wear and emissions. Applying neural networks to optimise the turbine inputs can improve results by 20% or more.

**Utility optimisation:** Optimising the purchase and consumption of utilities, such as power and water, according to real-time demands on a factory floor is too challenging and variable to manage using rules-based software. AI enables companies to anticipate, and align, utility consumption with process requirements in real-time, lowering utility consumption by 5% or more.

**Early stage UK companies include:**

| | |
|---|---|
| **Process Optimisation**<br>Flexciton<br>Materialize.X<br>CloudNC | **Predictive Maintenance**<br>Senseye<br><br>**IoT**<br>Thingtrax |

**AI can identify subtle patterns in data from vibration, temperature, pressure and other sensors to identify leading indicators of equipment failure.**

## Retail

E-commerce, now 17% of UK retail sales and growing (eMarketer), has transformed the quantity, breadth and granularity of data available to retailers. Retailers that turn data into insight can increase competitive advantage by engaging, monetising and retaining customers more effectively. Every stage of a retailer's customer journey – from lead generation and content selection to price optimisation and churn prediction – can be improved by AI algorithms that ingest richer data sets and identify patterns in them better than rules-based systems. By enabling analytics at the 'per-customer' level, AI is introducing the era of retail personalisation. Leaders enjoy competitive advantage; 75% of Netflix users select films recommended to them by the Company's AI algorithm.

**Customer segmentation:** Limitations in available data, and the linear analysis of information, inhibit the ability of traditional customer segmentation software to identify desirable customer attributes. Deep learning algorithms enable natural language processing, which lets retailers access additional data sets including social media data. Deep learning algorithms also offer more granular analysis than rules-based systems, to optimise segmentation, channel selection and messaging.

**Content personalisation:** Most content presented to online shoppers is irrelevant or poorly suited to users' preferences, reducing conversion to an average of 1.0% on smartphones and 2.8% on desktops (Adobe). As with customer segmentation, AI offers additional unstructured data sets for analysis, and improved multi-variate analysis to identify more subtle correlations than rules-based systems can detect. When Netflix recommends content to a user, in addition to analysing a user's actions, ratings and searches, the Company's AI algorithm considers social media data and meta-data from third parties.

The Company is now analysing images from content, including colour palette and scenery, for deeper personalisation.

**Price optimisation:** A 1% change in price provides, on average, a 10% change in profitability (BlueYonder). The smaller a company's margins, the greater the impact. Willingness to pay is a key determinant for price. AI enables price optimisation that is more sophisticated than traditional 'cost plus', 'relative-to-competitors' or 'odd pricing' (£0.99) models. By identifying correlations within and between data sets, AI can better optimise for factors including price elasticity, revenue, profit, product availability and phases in a product's lifecycle (introduction or end-of-life).

**Churn prediction:** Traditional programs struggle to incorporate new sources of information, maximise the value from multi-variate data sets or offer granular recommendations. AI-powered churn prediction can identify leading indicators of churn more effectively, and improve remediation by predicting more accurately the format and content of successful interventions.

**Early stage UK companies include:**

| | |
|---|---|
| **Analytics/Optimisation**<br>Boldmind<br>Hero | **Augmented Reality**<br>DigitalBridge<br>Metail |
| **Connected Device**<br>JCC Bowers<br>Third Space Auto | **Home Device**<br>Cocoon<br>Emotech |
| **Store Analytics**<br>Hoxton Analytics<br>Presence Orb<br>Proximus<br>ThirdEye | **Product Recommendation**<br>Cortexica<br>Orpiva<br>Pasabi<br>See Fashion<br>Thread |

**75%**

of Netflix users select films recommended to them by the Company's AI algorithms.

Source: Netflix

## Transport

**The transport sector will be transformed by AI. Breakthroughs in computer vision are enabling the age of autonomous vehicles – self-driving cars, buses and trucks. The implications, from shifts in sector value chains to new business models, will be profound (see Chapter 5). As well as enabling autonomy, AI can be applied to the many prediction and optimisation challenges – from congestion modelling to fleet management – at the core of today's logistics networks.**

**Autonomous vehicles:** AI computer vision systems enable vehicles to sense and identify the physical features and dynamics of their environment, from road lanes to pedestrians and traffic lights, with a high degree of accuracy. Combined with AI data processing and planning algorithms, AI is enabling the age of autonomous transport. Cars, buses and trucks will be able to operate and guide themselves, without human involvement. SAE International, a US-based global professional association and standards body, has identified five degrees of vehicle autonomy, from Level 0 (no automation) to Level 5 (full automation; no requirement for human control). Select companies, including Google, intend to release vehicles offering Level 5 automation. Challenged by the autonomous vehicle programmes of Google, Uber and Tesla, incumbent manufacturers are accelerating their own initiatives by increasing investment and making acquisitions. Ford intends to deliver high-volume availability of at least a Level 4 autonomous vehicle by 2021.

**Infrastructure and system optimisation:** AI's abilities to detect patterns and optimise complex data are being applied to traffic, congestion and infrastructure challenges in transport

systems. Predicting traffic flows, or modelling the deterioration of transport infrastructure, are difficult because inputs are complex (combining traffic, construction and environmental data) and because the relationships between inputs and outputs are non-linear (Transportation Research Circular). In these contexts, machine learning and deep learning systems are well suited to deliver better results than rules-based systems.

**Fleet management:** Transportation fleets are pervasive, from the logistics networks that underpin the economy to taxi fleets and food delivery services that provide point-to-point convenience. AI can optimise pick-ups, route planning and delivery scheduling to maximise asset utilisation, while taking into account economic, social and environmental impacts.

**Control applications:** Machine learning systems are well suited to the numerous prediction and optimisation challenges presented by air traffic control, vehicle traffic signalling, and train control.

**Early stage UK companies include:**

| **Autonomous Vehicles** | **Intelligent Infrastructure** |
|---|---|
| Baro Vehicles | Alchera Technologies |
| FiveAI | Open Capacity |
| Oxbotica | |
| Machines With Vision | **Location Intelligence** |
| Predina | NumberEight |
| | TravelAI |

**Supply management:** AI algorithms can predict changes in supply, including those caused by the intermittency of renewable resources, more effectively than rules-based systems – enabling smaller reserves and greater cost savings. AI solutions can also optimise supply networks, which are becoming increasingly complex as consumers deploy sources of renewable energy that contribute energy back to the National Grid.

**Demand optimisation:** By identifying detailed patterns in consumer behaviour, AI algorithms can move consumption of energy from periods of peak use and high prices to times of lower demand and cost.

**Security:** Rules-based systems struggle to deliver system security given the continually evolving nature of security threats. By identifying abnormal patterns in network behaviour, deep learning systems can identify breaches in network security that elude traditional programs.

**Customer Experience:** Chatbots, which offer natural language conversations powered by deep learning algorithms, offer consumers self-service account administration, product information and customer service.

**Early stage UK companies include:**

| **Grid Optimisation** | **Intelligent Energy Systems** |
|---|---|
| Biscuit | Green Running |
| Limejump | Grid Edge |

## Utilities

Information processing will become critical to utility companies, and their business models, as the utility sector undergoes a greater change in the next 25 years than it has during the previous 150. 'Prosumers' – consumers who also own capacity for energy production – will require integration into the energy market. By processing data more intelligently, AI will be a significant value driver in this transition. AI use cases for utility companies are varied, from demand optimisation and security to customer experience.

The foundations for AI adoption in the utilities sector are robust. 67% of utility companies – a higher proportion than in any other sector – use 'internet of things' (IoT) technologies such as sensors (Gartner). Further, compared with peers in other sectors, utility CIOs have a stronger focus on cost reduction, managing geographically dispersed assets and security.

**67%**

of utility companies – a higher proportion than any other sector – use 'internet of things' (IoT) technologies such as sensors.

Source: Gartner

### Business function case study

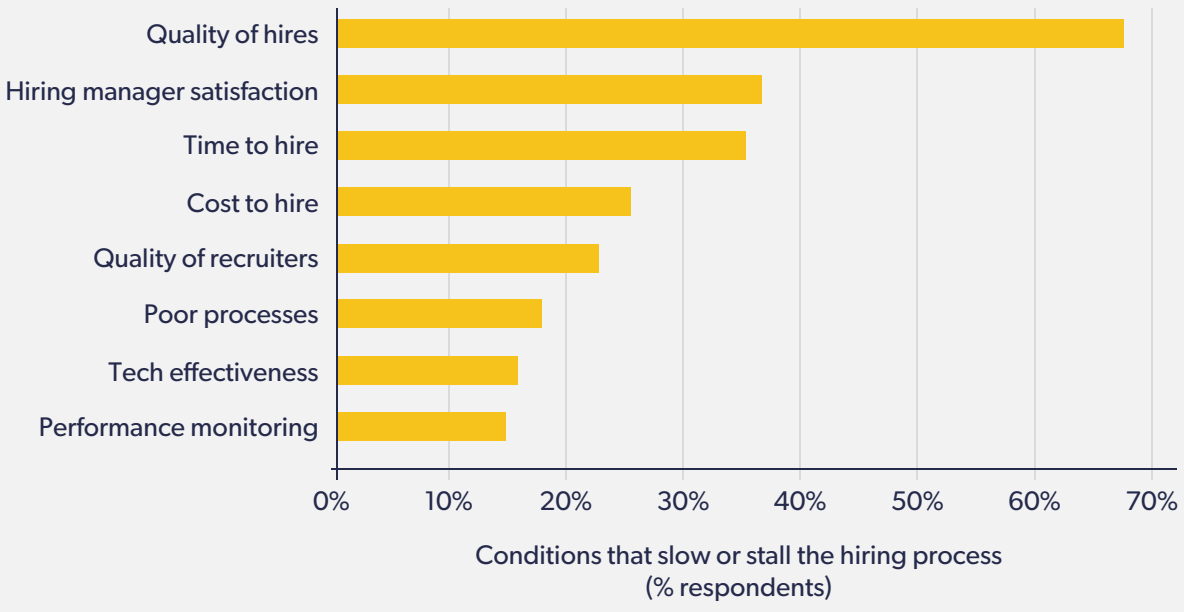
# Human Resources

**For an alternative perspective, we can explore the applications of AI for business functions ('horizontals' such as compliance, human resources, technology, sales or marketing) instead of sectors ('verticals'). Over time AI will become normalised – a part of developers' standard toolkit – used to improve, and then reinvent, business functions.**

In the human resources (HR) function, for example, AI is reducing costs and improving outcomes in sub-functions including recruitment, workforce management and learning.

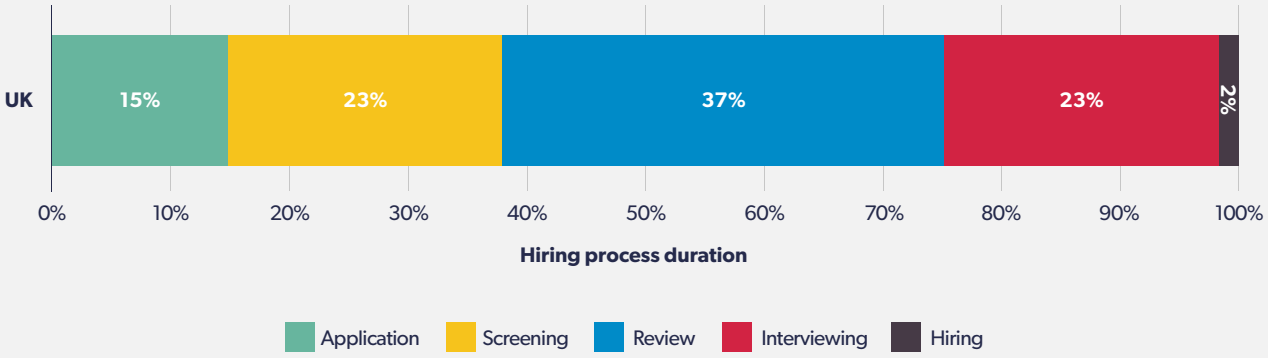
In recruitment, AI can address buyers' primary pain points (fig. 24): identifying high quality hires that meet hiring managers' criteria, reducing time-to-hire, and managing cost-to-hire (KellyOCG). Inefficiencies are considerable. On average, pre-interview screening of applicant CVs consumes 60% – more than 20 days – of a company's hiring process (iCIMS Inc) (fig. 25, overleaf). The challenge is exacerbated by an increasing number of applicants per role, a result of the proliferation of job boards and shorter average job tenure.

**Fig. 24. Quality, time and cost are key recruitment pain points**




Source: KellyOCG

**Fig. 25. Pre-interview screening and review occupies 60% of companies' hiring process**



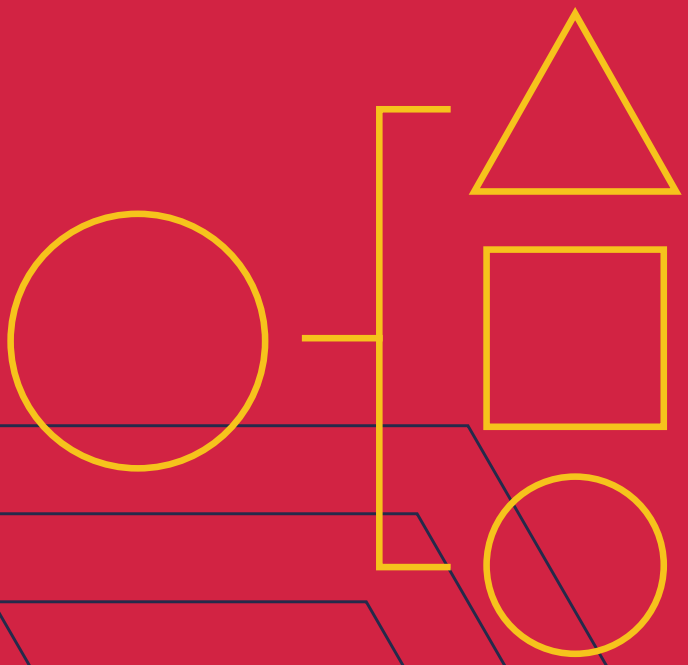

Source: iCIMS Inc.

Companies can improve **candidate targeting** by using AI-driven natural language processing to review social media profiles and develop fuller prospect profiles. AI can also identify patterns in disparate data sets – for example, visits to a Company's recruitment page and a person's affinity for certain brands – to enable outreach to prospects who are likely to engage. Further, by detecting indicative patterns of behaviour, AI enables companies to target 'passive candidates' – prospects who may be open to new roles but have not publicly begun a search.

During the **applicant screening** process, AI can reduce time- and cost-to-hire, increase hiring quality, and improve candidate experience. By extracting, structuring and identifying patterns in candidates' applications, AI solutions can automate a high proportion of first-round filtering. Chatbots can assist, soliciting missing information from candidates and boosting candidate engagement by answering their common questions scalably and at low cost. AI is also in the early stages of predicting a candidate's performance in a specific role, cultural fit, and probability of leaving. In technical roles, such as coding, AI can analyse candidates' published code and compare its quality and style to a desirable baseline. In other roles, by identifying correlations between candidate test result data and corporate performance information, AI can predict whether a candidate is likely to perform strongly in a particular role, or resign after a short tenure. This is highly valued in industries in which rates of churn, and therefore recruitment costs, are high.

Applying AI to HR presents challenges as well as opportunities. Vendors must overcome caution regarding new technology, procure access to disparate data sets, avoid reinforcing existing biases in decision-making, and address questions of explainability – what was the basis of their solution's recommendation?

**In recruitment, AI can address buyers' primary pain points: identifying high quality hires that meet hiring managers' criteria, reducing time-to-hire, and managing cost-to-hire.**



# Chapter 5

# The implications of AI

## Summary

- AI's value can be abstracted to four benefits: innovation (new products and services); efficacy (the performance of tasks more effectively); velocity (the completion of tasks more quickly); and scalability (the extension of capabilities to new market participants).
- These benefits will have significant implications for companies, consumers and society, including: the introduction of new market participants; shifts in sector value chains; new commercial success factors; shifts in companies' competitive positioning; new business models; shifts in skills and organisational design; accelerating cycles of innovation; and new benefits and risks to society.
- By automating capabilities previously delivered by human professionals, AI will reduce the cost and increase the scalability of services, significantly broadening participation in select markets.
- In multiple sectors AI will change where, and the extent to which, profits are made within a value chain.
- New commercial success factors will determine a company's ability to be successful in the age of AI.
- New leaders, followers, laggards and disruptors will emerge as the paradigm shift to AI causes significant shifts in companies' competitive positioning.
- AI, growth of 'x-as-a-service' consumption, and subscription payment models will obviate select business models and offer new possibilities in sectors including transport, insurance and healthcare.
- As AI gains adoption, the skills that companies seek, and companies' organisational structure, will change.
- By reducing the time required for process-driven work, AI will accelerate the pace of business and innovation. This may compress cycles of creative destruction, reducing the period of time for which all but a select number of super-competitors maintain value.
- AI will provide benefits to society including improved health, broader access to services and more personalised experiences. It will also present risks and dilemmas, including issues of job displacement, bias, conflict and privacy.

# Recommendations

## Executives

- Evaluate how the benefits unleashed by AI – innovation, efficacy, velocity and scalability – will impact your industry.
- Consider if AI can be used to reach new market participants and grow your addressable market.
- Assess the shifts in your industry value chain that will occur as AI adoption grows.
- Evaluate the business model a disruptor might adopt in the age of AI, if freed from the "innovator's dilemma". What would the Netflix to your Blockbuster look like?
- Assess the extent to which your company is developing the commercial success factors required for the age of AI.
- Companies' competitive positioning will change as adoption of AI increases. Develop an AI strategy to become a leader rather than a laggard.
- Evaluate the suitability of your company's skills and organisational design in light of changes AI will necessitate.
- Recognise the need for responsible stewardship. AI presents risks to society – including issues of job displacement, bias, and privacy – as well as benefits.

## Entrepreneurs

- Identify opportunities to take advantage of probable shifts in sector value chains that will be caused by AI.
- Develop initiatives that will take advantage of the new market participants and business models that AI will present.
- Identify weaknesses in incumbents' competitive positioning that are likely to persist, or worsen, given their structure or strategy.

## Investors

- Assess how the innovation, efficacy and scalability enabled by AI will impact your existing portfolio companies.
- Identify investment opportunities in sectors that will be transformed as a result of AI altering value chains and enabling new market participants.
- Evaluate opportunities to invest in companies structured around business models that will come of age as AI disrupts existing markets.
- When evaluating incumbents, assess the extent to which they could develop the commercial success factors required for success in the age of AI.

## AI will deliver innovation, efficacy, velocity and scalability

AI's value, from finding patterns in data more effectively to automating previously manual tasks, can be abstracted to four key benefits:

| Benefit | Explanation | Examples |
|---|---|---|
| Innovation | New products and services. | • Autonomous vehicles<br>• Voice-controlled devices |
| Efficacy | Perform tasks more effectively. | • Fraud detection<br>• Customer segmentation |
| Velocity | Complete tasks more rapidly. | • Legal document processing<br>• Manufacturing process optimisation |
| Scalability | Extend capabilities to additional market participants. | • Automated medical diagnosis<br>• Automated executive assistants |

Source: MMC Ventures

## AI will have significant implications

Innovation, efficacy, velocity and scalability will have significant implications for economic systems, employees, consumers and society. AI will lead to:

**1. New market participants**
**2. Shifts in sector value chains**
**3. New commercial success factors**
**4. Changes in companies' competitive positioning**
**5. New business models**
**6. Shifts in skills and organisational design**
**7. Accelerating cycles of innovation**
**8. Benefits and risks for society**

### 1. New market participants

**By automating capabilities previously delivered by human professionals, AI will reduce the cost and increase the scalability of services, significantly broadening participation in select markets.**

Today, access to sectors including healthcare and financial services is limited to subsets of the global population.

Medical diagnosis, for example, is inaccessible to people in developing economies and expensive for those in developed nations. Diagnosis has been undertaken by experienced professionals, whose training is time consuming and whose scalability is limited, inhibiting supply and increasing cost.

AI will provide automated diagnosis for a growing proportion of conditions. The marginal cost of diagnosing a patient with an AI algorithm will be nil. With smartphone adoption in developing economies increasing rapidly, from 37% in 2017 to an estimated 57% by 2020 (GSMA), barriers to access are also falling rapidly. By transferring the burden of diagnosis from people to software, global access to primary care will increase. Millions of additional individuals will benefit from primary care, while the market for providers of relevant and associated technologies will expand.

### 2. Shifts in sector value chains

**In multiple sectors AI will change where, and the extent to which, profits are made within a value chain.**

In the insurance sector, revenue from car insurance accounts for 42% of global insurance premiums (Autonomous Research). As AI-powered autonomous vehicles gain adoption, the frequency of accidents will reduce – and with them, insurers' revenue. UK car insurance premiums are expected to fall by as much as 63%, causing profits for insurers to fall by 81% (Autonomous Research). Insurers must anticipate and plan for a profound shift in their Sector's value chain.

In the legal services sector, clients are increasingly aware, and less willing to pay, for deliverables that have not required the time or expertise of an experienced lawyer. In March 2017, Deutsche Bank announced that it will no longer pay City law firms for legal work undertaken by trainees and newly qualified lawyers. The automation enabled by AI will broaden the range of tasks that can be provided to clients at low cost. As clients expect greater use of AI, cost pressures on routine work will increase and value will shift further to high-end work.

In the transport sector, automotive finance provides 19%, on average, of car manufacturers' pre-tax profits (MMC Ventures). Large automotive finance companies, including Ford Motor Credit, Toyota Financial Services, Nissan Motor Acceptance Corp and Hyundai Motor Finance loan consumers money to buy new cars. As we describe below ('New business models'), private vehicle ownership will reduce as subscription-based services provide consumers with on-demand access to fleets of autonomous vehicles. Demand for, and value in, automotive finance for consumers is likely to decline.

**42%**

of global insurance premiums come from car insurance

Source: Autonomous Research

**The automation enabled by AI will broaden the range of tasks that can be provided to clients at low cost. As clients expect greater use of AI, cost pressures on routine work will increase and value will shift further to high-end work.**

### 3. New commercial success factors

**New commercial success factors will determine a company's ability to be successful in the age of AI.**

A paradigm shift in technology offers companies new benefits while demanding new competencies. Cloud computing, for example, offered flexibility, scalability, reduced capital expenditure and faster upgrade cycles. However, it demanded new diligence processes, different supplier relations and dynamics, internal competencies in change management and paying greater attention to security.

Success factors in the age of AI include:

1. The vision to embrace AI and the organisational changes it requires.
2. Ownership of large, non-public data sets to train and deploy market-leading AI algorithms.
3. A willingness to evaluate the opportunities and risks of sharing training data with partners and competitors.
4. The ability to attract, develop, retain and integrate data scientists within an organisation.
5. The ability to form effective partnerships with best-of-breed third-party AI software and service providers.
6. The ability to diligence AI partners effectively.
7. A willingness to understand and respond to regulatory challenges posed by AI.
8. A shift in mindset to the use of software that provides probabilistic instead of binary recommendations.
9. The ability to manage workflow changes that result from the implementation of AI systems.
10. The ability to manage challenges of organisational design and culture as AI augments, and in some cases replaces personnel.

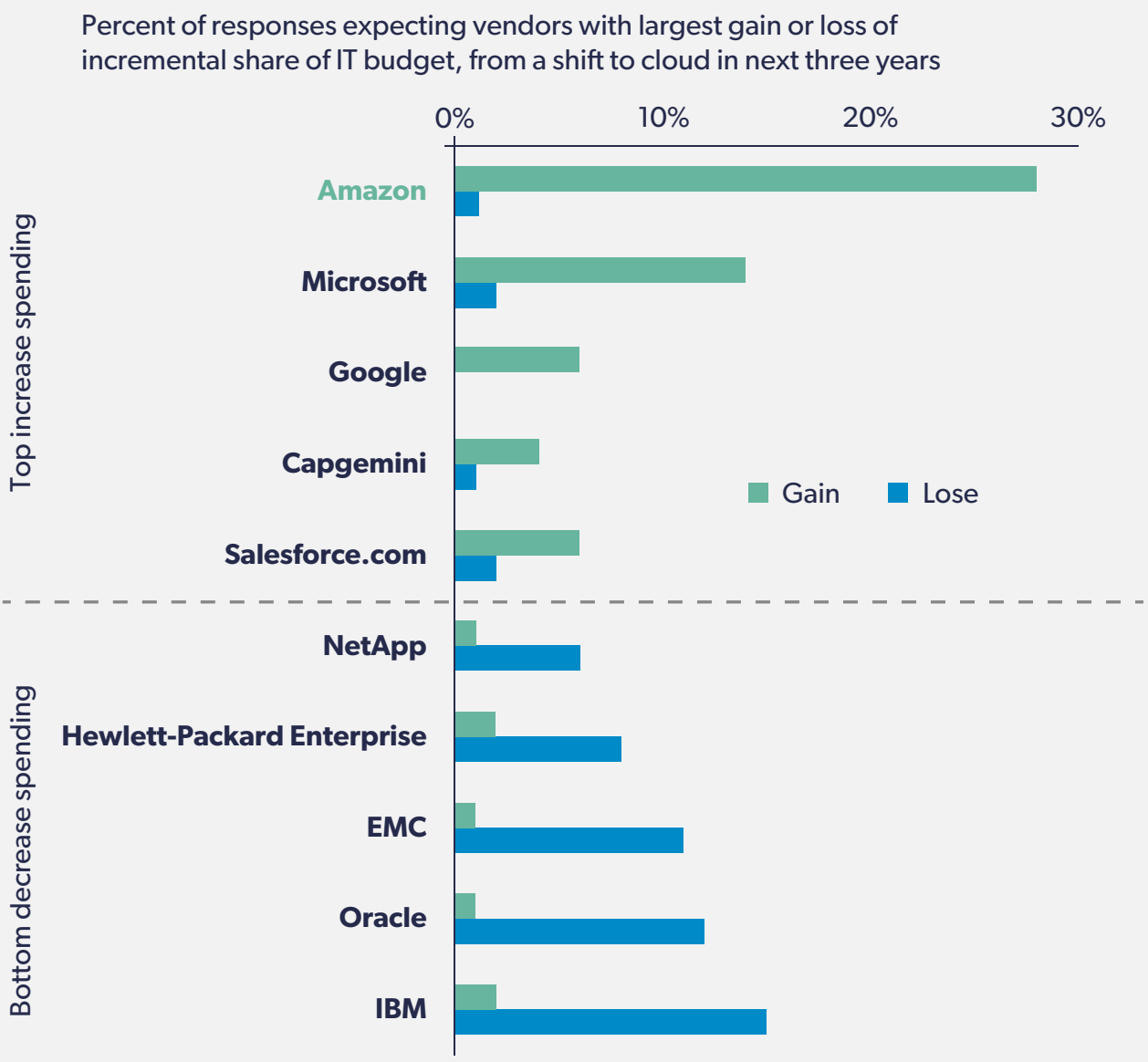
### 4. Changes in companies' competitive positioning

**New leaders, followers, laggards and disruptors will emerge as the paradigm shift to AI causes significant shifts in companies' competitive positioning.**

Paradigm shifts in technology destabilise incumbents and enable new leaders to emerge. As adoption of cloud computing continues, for example, IT spend is being reallocated to cloud-native platforms (such as Amazon) and applications at the expense of incumbents (fig. 26).

AI will cause greater shifts as it alters value chains, enables new business models and demands different success factors from competitors. We expect **'Platforms', 'Disruptors', 'Leaders'** and **'Laggards'** to emerge.

**Fig. 26. Paradigm shifts disrupt incumbents**




Source: AlphaWise, Morgan Stanley Research

**Among providers of AI:**

**Platforms** – primarily Google, Amazon, IBM and Microsoft (GAIM) – provide the AI infrastructure, development environments and 'plug and play' AI services used by many developers and consumers of AI. With vast data sets, world-class AI teams and extensive resources, select GAIM vendors are well positioned to accrue value as platforms that support the provision of AI.

GAIM do not, however, have the data advantage, expertise or strategic desire to address the myriad domain-specific use cases required by businesses in sectors ranging from manufacturing, agriculture and education to retail, professional services and finance. This presents opportunities for Disruptors.

**Disruptors** are early stage, AI-led software companies tackling business problems in a novel way using AI. For incumbents, Disruptors are a double-edged sword. Disruptors will enable the enterprises, small- and medium-sized businesses that embrace them, while eroding the value of those that lack the foresight to do so. Select Disruptors will become tomorrow's incumbents or be acquired by today's.

**Among buyers of AI** (today's enterprises, and small and medium-sized businesses):

**Leaders** will emerge in key industries, by: anticipating the shifts in value chains and business models caused by AI; taking advantage of their large, proprietary data sets to train and deploy AI algorithms; having the organisational ability to deploy AI effectively; and by having sufficient resources and reputation to attract high quality AI talent. Leaders will extend their competitive advantage and enjoy particular benefits:

1. In the 'data economy', economic returns will accrue disproportionally to companies that can extract value from information most effectively.
2. Data network effects create wider competitive moats. Larger volumes of training data enable better algorithms, which deliver better products and services, which win more customers, who provide more data. Leaders will benefit from data network effects that competitors will struggle to overcome.

**Laggards** are buyers that lack the will or organisational ability to use AI effectively. While some enterprises will lack the foresight to adapt, more will falter due to limited organisational capability. Laggards will: move slowly to partner with Disruptors or invest in their own AI teams; fail to take advantage of the extensive data sets and resources at their disposal; and struggle to attract AI talent. In the 'data economy', laggards will lose competitive advantage and market share significantly and rapidly.

**5. New business models**

**AI, growth of 'x-as-a-service' consumption, and subscription payment models will obviate select business models and offer new possibilities in sectors including transport, insurance and healthcare.**

The greatest impact of new corporate and consumer technologies is the new business models they enable, not the technical capabilities they provide.

In the transport sector, AI will transform the economic fabric of ownership and insurance. Cars are parked for an average of 96% of their lives (UITP Millennium Cities Database). Despite the cost and inefficiency of private car ownership, the model has been necessary to enable spontaneity, point-to-point convenience, comfort, privacy and security during travel. An autonomous vehicle, summoned whenever required from a distributed fleet and used for the duration of a journey, will offer the same benefits while optimally utilising a fleet. With the cost of the driver removed, and the cost of the vehicle and insurance divided over a greater volume of trips in a given period, the marginal cost of a journey will be lower. With growing use of transport-as-a-service subscription models, in which consumers pay a low monthly fee for on-demand access to a fleet of autonomous vehicles, private car ownership is likely to decline.

The impact on 'downstream' market participants will be as significant. The business models of local car dealerships, vehicle repair centres, petrol stations and charging centres will change as local ownership of private vehicles is displaced by large, managed fleets.

In the insurance sector, associated business models will be disrupted. The object of car insurance is likely to change, from a driver (who will play no role in an autonomous vehicle's operations) to the vehicle manufacturer or service provider. The immediate buyer of car insurance will also change, from the end user to the manufacturer or service provider. (Ultimately, the fee will be repaid by the end user as a small component of their monthly subscription fee). Accordingly, insurers' business models in the automotive sector may shift from private policies to fleet-based agreements. Today, 87% of car insurance policies are personal, not commercial. This may fall to 40% (Autonomous Research).

### 6. Shifts in skills and organisational design

**As AI gains adoption the skills that companies seek, and companies' organisational structure, will change.**

As companies vie for leadership in the AI era, companies will seek different personnel and change the organisational principles around which they are structured.

41% of companies are considering the impact of AI on future skill requirements (PWC). A mix shift to employing data scientists is likely. Data scientists extract meaning from data by collating, cleaning and processing data and then applying statistical techniques and AI algorithms. Companies' engagement with data scientists is limited today. For example, while the world's largest professional services and consulting firms average 5,000 to 15,000 in-house analytics professionals, we estimate that fewer than 8% of these are data scientists (MMC Ventures). Some large companies have as few as 100 data scientists. Tomorrow's leaders are aggressively expanding their data science teams, recognising that time to market is key because of the potential for competitive advantage through data network effects (more data yields better algorithms, which provide improved products that attract more clients and data).

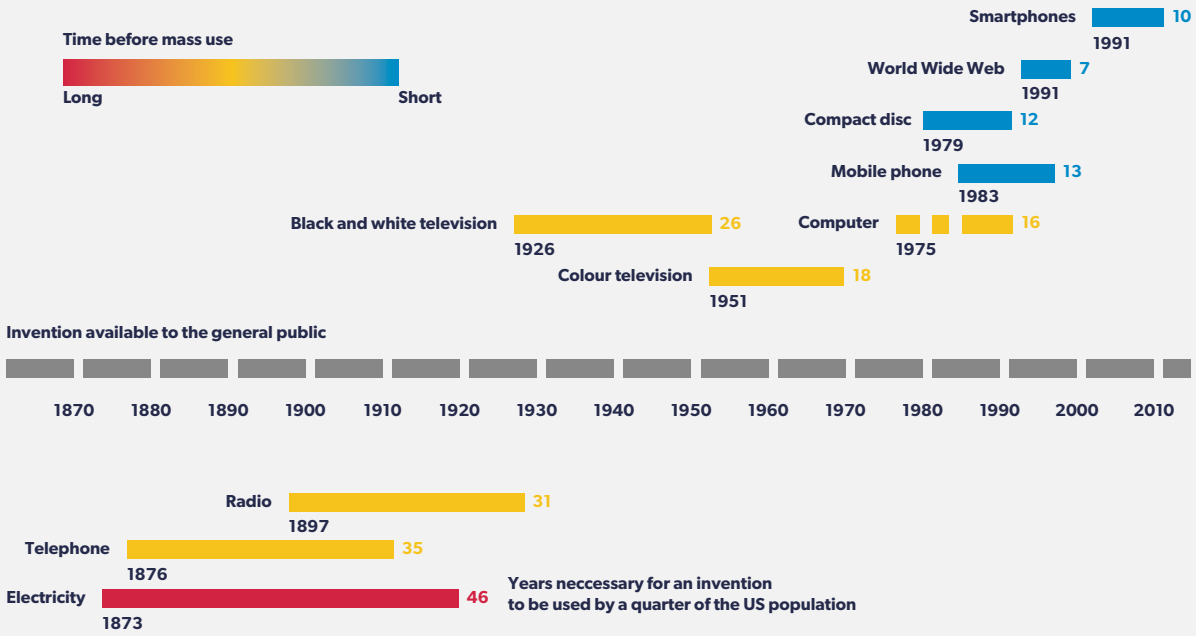
While adjusting their mix of personnel, companies will alter their organisational design. Hiring for adaptability will be increasingly important, as the range of tasks supported or undertaken by AI systems increases. One in three companies are redesigning their organisational structures from traditional hierarchies to multi-disciplinary teams (Deloitte) to enable greater adaptability.

### 7. Accelerating cycles of innovation

**By reducing the time required for process-driven work, AI will accelerate the pace of business and innovation. This may compress cycles of creative destruction, reducing the period of time for which all but a select number of super-competitors maintain value.**

With several occupations, and numerous constituent activities, automated or augmented with AI, the speed at which tasks can be completed will increase. By accelerating the pace of business, AI is likely to shorten cycles of innovation, adoption and consumption that have been compressing since the 1950s (fig. 27).

**Fig. 27. Cycles of innovation, adoption and consumption are compressing**




Source: European Environment Agency, based on Kurzweil

Historically, accelerating cycles of innovation have reduced the period of time for which large companies retain value. In 1965, companies in the S&P500 stayed in the index for an average of 33 years (Innosight). By 1990, average longevity had narrowed to 20 years. By 2012, 18 years was typical. By 2026, average tenure in the S&P500 is forecast to shrink to 14 years (Innosight). While reduced longevity in stock market indices arises partly due to technical factors, such as increasing merger and acquisition activity, creative destruction of incumbents has been accelerating. Faster cycles of disruption due to AI could reduce, further, large companies' ability to maintain value.

However, the dynamics of AI, and today's market leaders, may result in a bifurcation in longevity and the emergence of a small number of super-competitors. Three factors could lead to the emergence of super-competitors that maintain value for longer than companies in recent history.

First, AI offers network effects through data. Because training AI algorithms typically requires large volumes of data, companies with large, proprietary data sets can deliver more effective AI systems. Superior systems provide better results, which attract more customers, who bring additional data – creating a virtuous circle and powerful defensibility. Several of today's largest technology companies including Google, Amazon, Apple and Microsoft have vast consumer data sets inaccessible to Disruptors.

Second, today's leading technology companies are investing, and expanding, into emerging technologies and product categories more forcefully than many companies in the past. Leading technology companies are disrupting themselves. Google, a company conceived to index pages on the world wide web, has become a leader in autonomous vehicles and quantum computing. Amazon, a company that sold books online, is becoming a force in so many sectors that the Company is mentioned on 10% of all US company quarterly earnings calls (Reuters).

**Today's leading technology companies are investing, and expanding, into emerging technologies and product categories more forcefully than many companies in the past.**

Third, select 21st century technology companies are consolidating power by expanding up, and down, the technology 'stack'. Providers of cloud storage, such as Amazon and Microsoft, are layering ever-higher levels of functionality – such as AI and security – into the environments they provide. Technology leaders are also expanding down the technology stack. Google and Apple now develop their own microprocessors for competitive advantage in mobile and AI computing. By expanding up and down the technology stack, companies can consolidate control and customer spend.

The combination of data network effects, greater investment in emerging technologies and product categories, and expansion up and down the technology stack may enable a small number of super-competitors to capture and maintain economic influence for a longer period of time than has been possible in recent history – amidst a broader bifurcation in corporate longevity.

**The dynamics of AI, and today's market leaders, may result in a bifurcation in companies' longevity and the emergence of a small number of super competitors.**

### 8. Benefits and risks to society

**AI will provide benefits to society including improved health, broader access to services and more personalised experiences. It will also present challenges and dilemmas, including issues of job displacement, bias, conflict and privacy.**

The **benefits** of AI for societies will be profound and numerous. They include: broader access to better and less expensive healthcare; increased mobility and fewer accidents; broader access to lower cost legal services; increased agricultural productivity and manufacturing capability; more efficient and satisfying retail experiences; improved management of financial assets and risk; accelerated cycles of innovation; and greater day-to-day convenience.

AI will also present significant **challenges** and dilemmas. **Job displacement** is a significant risk associated with the proliferation of AI. AI will directly enable the automation of several occupations that involve routine and repetition – from

driving to telemarketing. Truck driving comprises 3.6 million jobs in the US (American Trucking Association). In many other occupations, AI will augment and then displace some workers in more complex roles, while reducing the need for additional workers to be hired as companies expand. In about 60% of occupations, at least 30% of constituent activities are technically automatable by adapting currently proven AI technologies (McKinsey Global Institute).

Analysis of UK census data since 1871 shows that historically, contracting employment in agriculture and manufacturing – a result, in part, of automation – have been more than offset by rapid growth in the caring, creative, technology and business service sectors (Deloitte). Greater automation of both manual and business service roles, however, may concentrate employment further in occupations resistant to automation, including care work and teaching. Whether or not, over time, AI creates more jobs than it destroys, the short time frame in which a large number of workers could be displaced, coupled with a reduction in the availability of similar roles, could prevent those who lose their jobs from being rapidly re-absorbed into the workforce. Social dislocation, with political consequences, may result.

**Whether or not AI creates more jobs than it destroys, the short period of time in which a large number of workers could be displaced, coupled with a reduction in the availability of similar roles, could prevent those who lose their jobs from being rapidly re-absorbed into the workforce.**

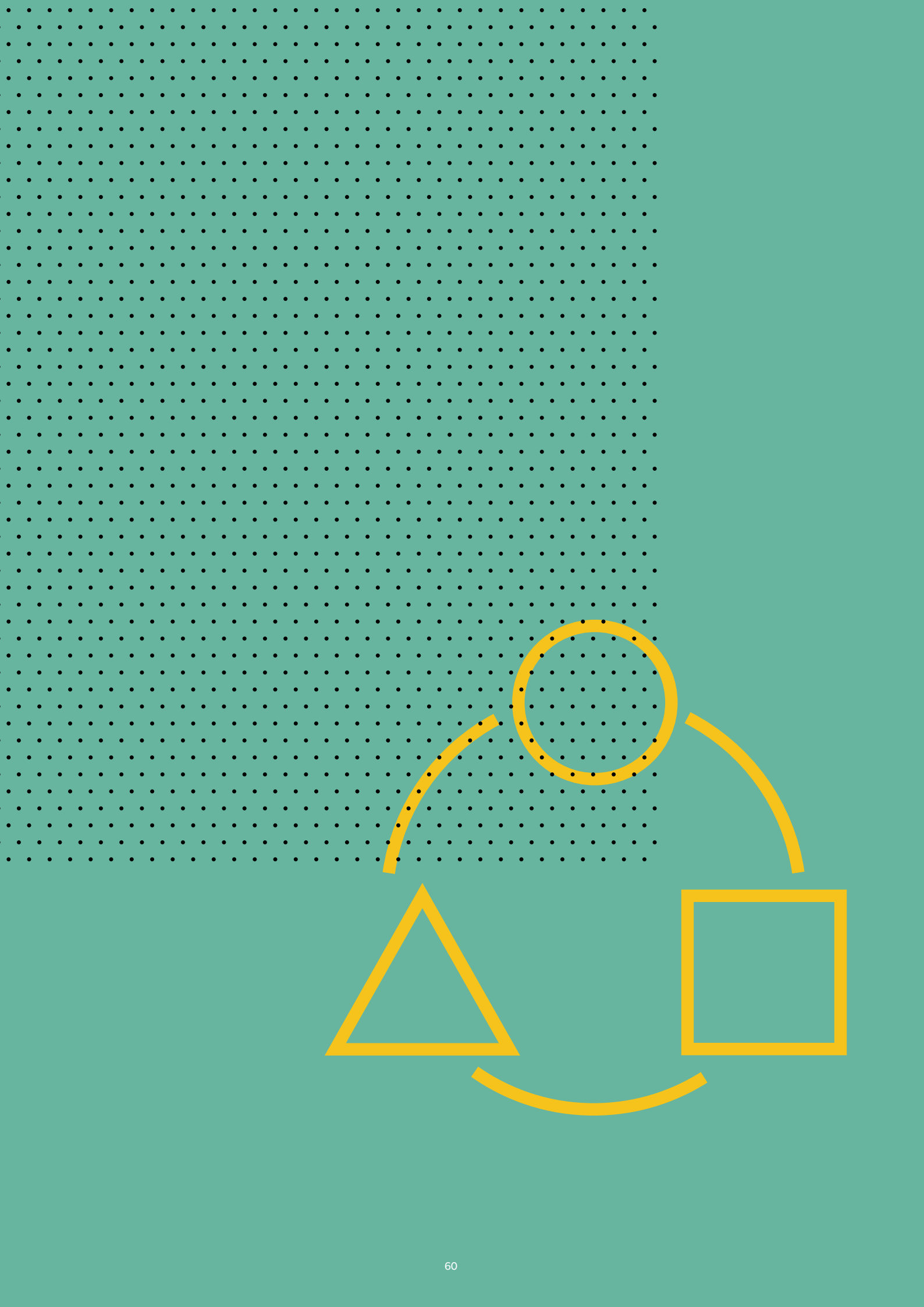
A second risk is that AI reinforces existing **social inequalities** and prejudices. AI has the potential to free decision-making from human bias by finding objective patterns in large data sets. However, AI systems learn by processing training data. The data sets available reflect systemic historic biases, including those of gender and race. The results from 'word embedding', an AI technique that has proven effective at interpreting written and spoken language, are an example. Word embedding creates mathematical representations of language. The meaning of a word is abstracted to a set of numbers based on the words that frequently appear near to it. However, when trained on the Common Crawl data set (a 145-terabyte collection of data taken from material published online), the word 'women' is closely associated with occupations in the humanities and the home, while 'man' is associated closely with science and technology professions (Caliskan, Bryson and Narayanan). From recruitment decisions to the provision of loans, algorithms will make decisions that have significant ramifications for individuals. Unless issues of bias are recognised and addressed, algorithms may learn and reinforce human prejudices.

The proliferation of autonomous weapon systems pose an additional risk. Weapon systems have incorporated a degree of autonomy for decades. The Phalanx CIWS weapon system, for example, defends ships in 20 countries' navies from missile attacks. The Phalanx combines a 20mm rotating Vulcan cannon with an automated system to interpret radar data, decide whether a target is a threat, and engage it. However, the combination of AI-powered computer vision systems, AI-based decision-making algorithms, and improved robotics, empower humanoid and aerial drones with greater capability and autonomy. The risk of 'killer robots' turning against their masters may be overstated. Less considered is the possibility that **conflict between nations** may increase if the human costs of war are lower. A country that thinks twice about sending young people into conflict may be more adventurous if the only assets in harm's way are equipment.

Governments and citizens will also need to re-evaluate the **balance between security and privacy** they desire. AI-powered facial recognition systems offer unprecedented capability. This technical evolution coincides with the proliferation of high resolution cameras. Every smartphone owner carries a camera in their pocket, while over 1.85 million CCTV cameras were in place in the UK as early as 2011 (Cheshire Constabulary Camera Survey). On average, a citizen is captured on CCTV an estimated 68 times per day (ibid). To what extent will citizens and governments be willing to sacrifice anonymity and privacy to prevent and detect crime?

**On average, a citizen is captured on CCTV an estimated 68 times per day**

**Cheshire Constabulary Camera Survey**



# Chapter 6

# The adoption of AI

## Summary

- Awareness of AI has reached an inflection point. Given media attention and vendor marketing, executives' awareness of AI is high.
- Understanding of AI among buyers is low. Technology principles, use cases and deployment methodologies are poorly understood.
- 20% of AI-aware executives say they have adopted one or more AI-related technology at scale, or in a core part of their business (McKinsey Global Institute). While nascent, we believe AI adoption is 'crossing the chasm' from innovators and early adopters to the early majority.
- Adoption of AI will increase significantly as buyers seek to unlock value from data and avoid losing competitive advantage. 75% of executives say AI will be "actively implemented" to some degree in their organisations within three years (Economist Intelligence Unit).
- High tech, automotive and assembly, and financial service firms lead AI adoption. Spending on AI will increase most in sectors that currently lead adoption.
- Poorly articulated business cases weigh on adoption. Better articulation of ROI by AI vendors can catalyse adoption.
- While extensive media attention and numerous pilot projects relate to chatbots, more than two thirds of buyers are deploying AI to improve decision-making and enable process automation.
- For mid-size and large companies, the C-suite is key for initiating, selecting and funding AI initiatives. In two thirds of organisations, the CTO or CIO make AI technology decisions given its cross-functional implications.
- AI deployment strategies are varied, with a mix of 'build' and buy' strategies, and in a state of flux. 'Hybrid' approaches are typical. A quarter of companies deploying AI today prefer to purchase a standalone solution.
- Lack of skills is the primary challenge for companies deploying AI. Defining an AI strategy, identifying use cases for AI, and securing funding for AI initiatives are additional difficulties.

# Recommendations

## Executives

- Adoption of AI is nascent but has passed a tipping point. Develop an AI strategy to avoid losing competitive advantage.
- Understanding of AI within your organisation is likely to be low. Develop initiatives to improve senior executives' understanding of AI by engaging with third-party experts.
- Increasingly, peers are investing in AI to gain value from their data. Ensure AI initiatives are a budget priority to enable test-and-learn deployments.
- Engage with AI software companies that articulate tangible use cases and ROI opportunities. Seek vendors offering solutions to business problems, not slogans.
- While chatbots receive extensive attention, recognise that your peers are more likely to be deploying AI to enhance business decision-making and process automation.
- Support the C-suite's efforts to catalyse AI. They are likely to be the initiator of AI initiatives and will play a significant role in selecting and funding projects.
- Proactively address the likely challenges to your organisation's adoption of AI: lack of skills; the absence of an AI strategy; lack of clarity regarding AI use cases; and prioritisation of funding.

## Entrepreneurs

- To address buyers' caution regarding AI technology, articulate solutions to business problems and ROI opportunities, not AI technology as an end in itself.
- Recognise that buyers' understanding of AI is low, and they are likely to lack AI skills and personnel within their organisations. Become a strategic partner for customers by offering education and support.
- Offer buyers improved decision-making and process automation to align with their priorities.
- Given the importance of the C-suite in initiating and funding AI initiatives at large companies, prioritise securing senior sponsorship for your initiatives.
- A quarter of buyers prefer AI solutions from independent software vendors. Qualify these attractive prospects early in your engagement process and highlight the benefits you can offer as a best-of-breed vendor.
- Proactively address buyers' potential concerns regarding product scalability and performance.

## Investors

- AI adoption is nascent, but crossing a tipping point from early adopters to the early mainstream. Identify opportunities to invest in AI-first companies that can capitalise on increasing demand for AI.
- Understanding of AI among buyers is limited, and C-level sponsorship may be required for deployments in large companies. Given these go-to-market dynamics, evaluate management teams' ability to articulate to buyers tangible solutions to business problems, and their C-level account management skills.
- Prospects that provide solutions aligned with buyers' priorities – improved decision-making and process automation – may be most attractive.

## Awareness of AI has reached an inflection point

Given media attention on AI and vendors' marketing of the technology, awareness of AI is high among executives at mid-size companies and large enterprises.

Interest has also passed an inflection point. "In January 2016, the term 'artificial intelligence' didn't even make it into the top 100 search terms on gartner.com. But just a year later, the term ranked at No. 11, and in May 2017 the term ranked at No. 7, indicating the popularity of the topic and interest from Gartner clients in understanding how AI can and should be used as part of their digital business strategy" (Gartner (August 2017) – Survey Analysis - Enterprises Dipping Toes Into AI but Are Hindered by Skills Gap).

**"The buzz over artificial intelligence has grown loud enough to penetrate the C-suites of organisations around the world."**

**McKinsey Global Institute**

## Understanding of AI is low

There is a gulf between buyers' awareness of AI and their understanding of the technology. Companies' understanding of AI is low. Technology principles, use cases and deployment methodologies are poorly understood. "Even among CIOs, understanding of AI is extremely low." (Senior Executive, global consumer packaged goods company).

**"Understanding of AI? it's probably a 3 out of 10."**

**Vice President, global consumer products company**

## AI adoption is 'crossing the chasm'

In a survey of 3,073 AI-aware C-level executes across ten countries and 14 sectors (fig. 28 overleaf), 20% said they had adopted one or more AI-related technology at scale, or in a core part of their business (McKinsey Global Institute).

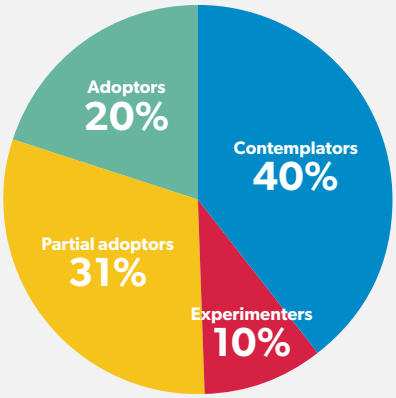
We believe adoption of AI is spreading from innovators (the first 2.5% to adopt a technology) and early adopters (the next 13.5%) to the early majority (the subsequent 34%) (fig. 29 overleaf).

AI adoption is, nonetheless, nascent. Just 10% of AI-aware companies have deployed three or more AI technologies (McKinsey Global Institute). 80% of companies that are aware of AI are gathering knowledge about the technology, developing strategy or experimenting with the technology (ibid). Engagements begin with proof-of-concept projects. Our conversations with senior executives underscore the early stage of the paradigm shift to AI, which will unfold within the enterprise in the coming decade and beyond.

**"The current AI wave is poised to finally break through."**

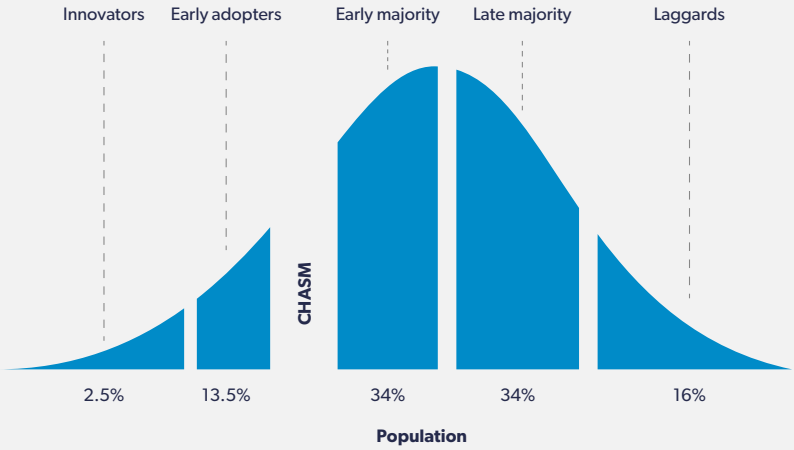
**McKinsey Global Institute**

**Fig. 28. 20% of AI-aware companies have begun adoption**




Source: McKinsey Global Institute

**Fig. 29. AI adoption is 'crossing the chasm' to the early majority**




Source: Everett Rogers, Geoffrey Moore

## Adoption will increase significantly

While understanding of AI is limited, there is significant appetite for AI investment as buyers seek value from data and wish to avoid losing competitive advantage. 75% of executives say AI will be "actively implemented" to some degree in their organisations within three years (Economist Intelligence Unit).

**"If we don't embrace AI, it may be that we lose competitive advantage."**
**Manager, utility company**

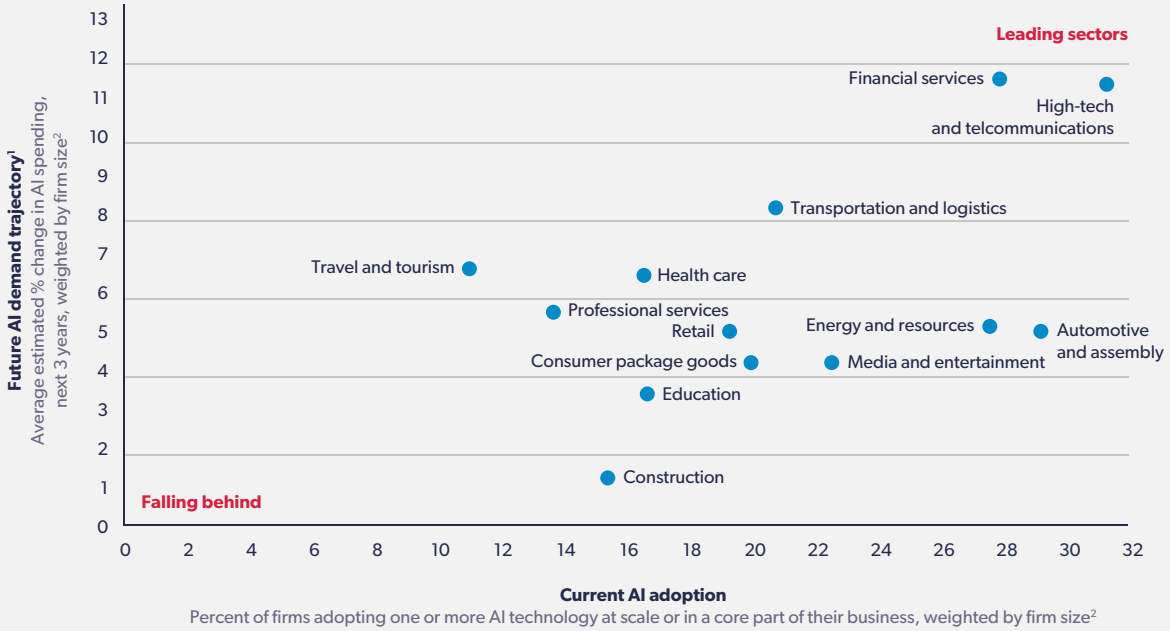
Our discussions with executives highlight their intention to invest in AI. "We understand that machine learning is needed within the business. It's an eight or nine out of ten in terms of deployment priorities" (Chief Finance Officer, UK internet retailer). "We have a huge amount of data. We play with it. We don't actually use it. That needs to change" (Chief Information Officer, global ecommerce company). "I do intend to deploy advanced, machine learning-led analytics within the next couple of years" (Chief Digital Officer, UK transport company). "I get it, and my boss does, so in the near future it will be part of our toolset" (Product Manager, global equipment supplier).

## High-tech and financial service firms lead adoption and demand

Adoption of AI is greatest in the following sectors (fig. 30 overleaf): high-tech and telecommunications; automotive and assembly; financial services; energy and resources; media and entertainment; and transportation and logistics (McKinsey Global Institute). Companies in these sectors encounter numerous prediction and optimisation challenges that can be addressed with AI, have large data sets to train and deploy AI algorithms, can readily assess the return on investment (ROI) offered by AI, face unattractive alternatives to digitisation in the form of expensive personnel, and have the resources and technological foresight to embrace new technologies.

Spending on AI will increase most in sectors that currently lead adoption. Companies in the financial services and high-tech and telecommunications sectors are likely to increase their AI expenditure most in the next three years (McKinsey Global Institute).

**Fig. 30. High-tech and financial services firms lead demand for AI**




Source: McKinsey Global Institute AI adoption and use survey; McKinsey Global Institute analysis
(1) Based on the midpoint of the range selected by the survey respondent. (2) Results are weighted by firm size.

## Poorly articulated business cases weigh on adoption

While positive about the potential for AI, many executives express nervousness around undertaking AI initiatives given suppliers' failure to articulate solutions to specific business problems, difficulty demonstrating ROI, over-promising by suppliers and the failure of some high-profile projects. 41% of firms say they are uncertain about the benefits of AI (McKinsey Global Institute).

**"Buyers feel there's value, but are nervous around making bets."**

**Vice President, global consumer products company**

Further, buyers are still implementing or consolidating prior investments in data management, including data lakes and reporting tools. Many have significant data collection, consolidation and harmonisation challenges to address before investing in AI. "We, and our peers, are trying to get our data infrastructure in place first" (Manager, UK utility company).

## A focus on ROI can catalyse spend

**"The key is transforming the messaging to make it simple to play back to the organisation: 'this will achieve your target'".**

**Director, UK service company**

To unlock value in the market, providers must articulate and deliver a tangible return on investment (ROI). Whether impacting direct drivers of revenue (uplift, conversion, yield or price) or reducing a company's excess spend or resource requirements, a provider's results will be assessed against a buyer's existing process and key performance indicators. To their cost, certain providers offer 'AI technology' without articulating business value. In a market driven by measurable results, not perceived gains, companies delivering tangible benefits enjoy a competitive advantage.

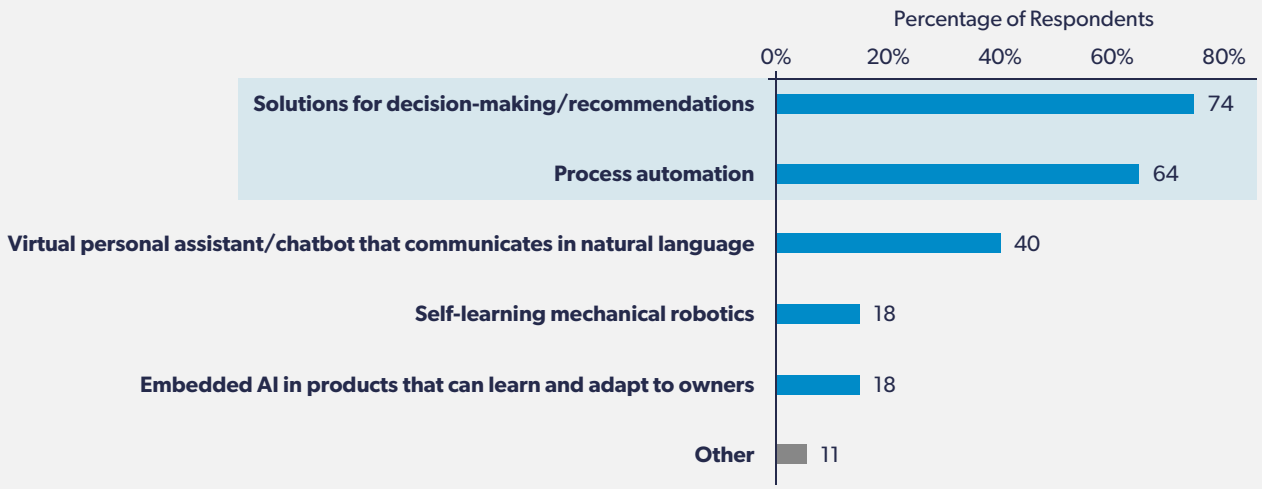
## Deployments focus on analytics and process automation

While extensive media attention and numerous pilot projects relate to chatbots, more companies are deploying AI to improve their ability to make decisions, or enable process automation (fig. 31).

While there is a novelty to innovations such as chatbots, organisations are more pragmatic, with 74% saying they want to apply AI to improve decision making and offer more personalised recommendations, especially in relation to customers (Gartner*). And, nearly two-thirds of surveyed organisations plan to use AI to automate business processes, especially in areas that are manually intensive (ibid). All other AI use cases, combined, account for fewer than half of deployment goals.

By focusing on decision-making and process automation, companies will unlock two of the fundamental benefits of AI: effectiveness and efficiency. Finding subtle correlations in data enables companies to improve their analyses and actions, while automating business processes offers reduced costs and accelerated innovation.

**Fig. 31. Business use case for using AI within organisation**




Base: n = 80, Gartner Research Circle Members; excludes "Haven't decided yet". Question: What type of artificial intelligence initiatives(s) is your organisation investigating/developing/has your organisation deployed or is planning to deploy?

*Source: Gartner (August 2017) – Survey Analysis - Enterprises Dipping Toes Into AI but Are Hindered by Skills Gap (Fig. 2).

## Lack of skills is the primary inhibitor to AI adoption

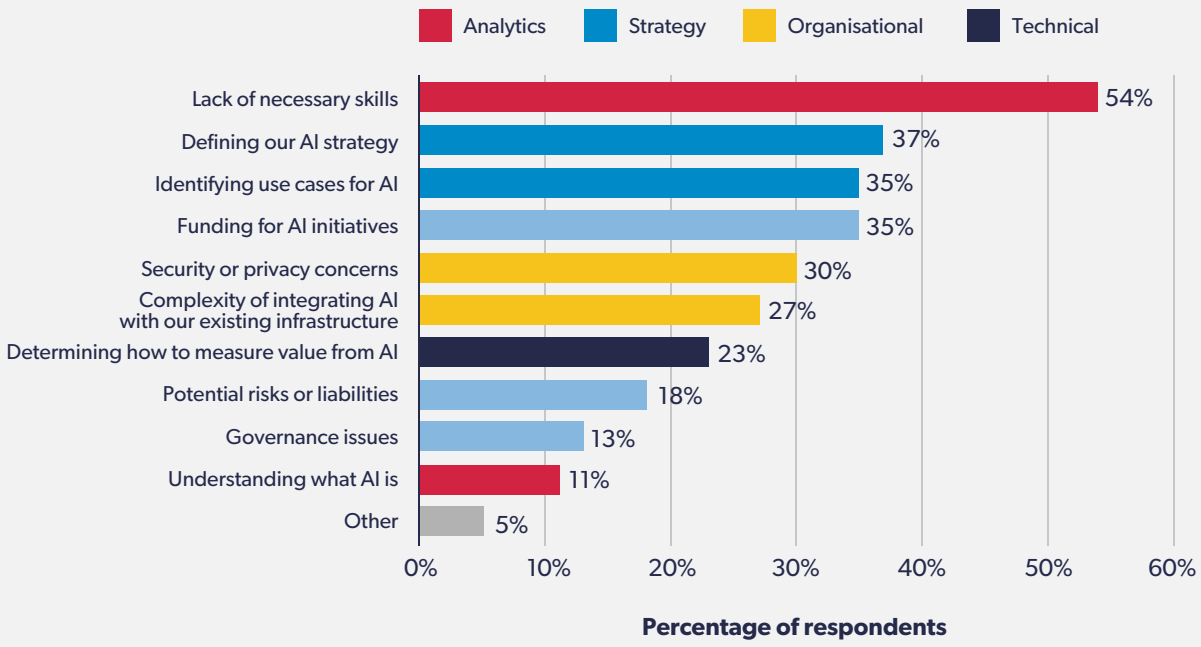
Most respondents to a Gartner survey report that lack of skills is the top challenge to adopting AI. Defining an AI strategy, identifying use cases for AI (fig. 32), and funding AI initiatives are the next most common difficulties (Gartner*).

These challenges are symptomatic of the early stage of a new technology paradigm. As mobile computing began to gain traction, companies struggled to define their mobile strategy, clarify use cases for smaller form factors, and hire enough designers and developers with mobile expertise.

**"At the end of the day, we just don't have the expertise in-house."**

**Product Manager, global equipment supplier**

**Fig. 32. Top three challenges to adopting AI by organisations**




Base: n = 83, Gartner Research Circle Members
Question: What are the top three challenges to the adoption of artificial intelligence within your organisation?

*Source: Gartner (August 2017) – Survey Analysis - Enterprises Dipping Toes Into AI but Are Hindered by Skills Gap (Fig. 4).

Lack of necessary skills is the greatest inhibitor of companies' adoption of AI. High quality data scientists, AI engineers and AI researchers are in short supply. In the UK, the number of open positions for general data scientists grew 32% year-on-year during the first half of 2016 (Procorre), for example, outstripping growth in supply. In the US, demand for data scientists and data engineers is projected to grow 39% (Burning Glass Technologies). With 81% of data science and analytics jobs requiring workers with 3-5 years of experience or more (ibid), the problem will not be resolved in the near-term and will serve has a headwind to the pace of AI adoption. Many new AI experts are being recruited by AI platform companies (Google, Amazon, IBM, Microsoft), by consumer technology companies (Apple, Facebook) or are choosing to found new AI-driven startups.

Companies' secondary challenges – defining an AI strategy, identifying use cases for AI, and securing funding for AI initiatives – will ease within the next three years. There are numerous use cases for AI that offer tangible benefits. Understanding of the technology and these use cases will improve. As pilot projects mature, demonstrable ROI will unlock funding. While at times buyers will experience disappointment, secondary challenges will slowly lessen over time.

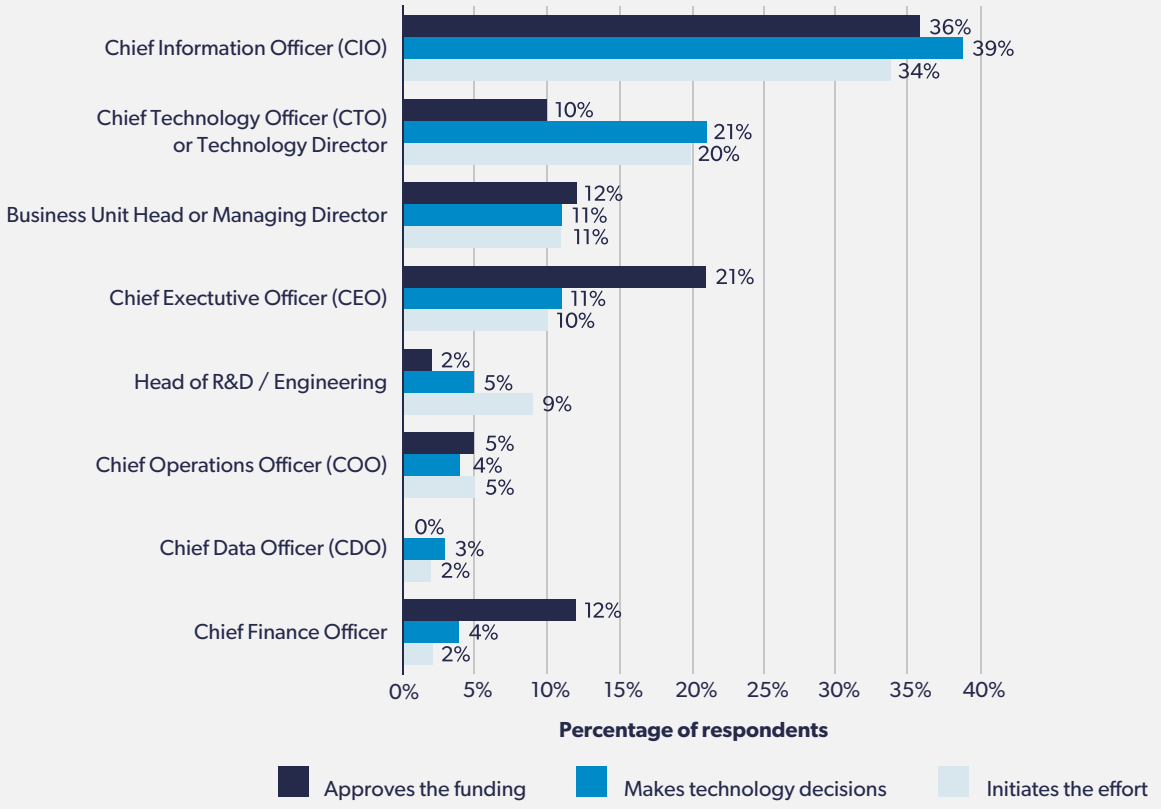
## The C-suite is key for initiating, selecting and funding AI initiatives

For large and mid-size organisations, the C-suite plays a vital role in initiating AI projects, making technology decisions in relation to them, and approving project funding (fig. 33). This reflects the C-suite's recognition of the strategic importance of AI, and a belief that the CIO is an appropriate lead for AI initiatives given the cross-functional implications of AI and its impact to existing systems.

Chief Information Officers (CIOs) and Chief Technology Officers (CTOs) are primary decision-makers. Together, they are responsible for initiating AI initiatives in more than half of organisations, and making technology decisions in nearly two thirds. The Chief Executive Officer (CEO) also plays a significant role, initiating AI initiatives in a tenth of organisations and approving funding in over a fifth. Chief Financial Officers' (CFOs') engagement with AI initiatives are primarily to approve funding, in just over a tenth of organisations.

**Chief Information Officers (CIOs) and Chief Technology Officers (CTOs) are the primary decision-makers.**

**Fig. 33. AI initiator and decision-making roles within organisation**




Base: Initiated the effort, n = 82; make technology decisions, n = 80; approves the funding, n = 81; Gartner Research Circle Members; excludes "Not sure".
Question: Who in your organisation primarily initiated the artificial intelligence initiative?

*Source: Gartner (August 2017) – Survey Analysis - Enterprises Dipping Toes Into AI but Are Hindered by Skills Gap (Fig. 5).

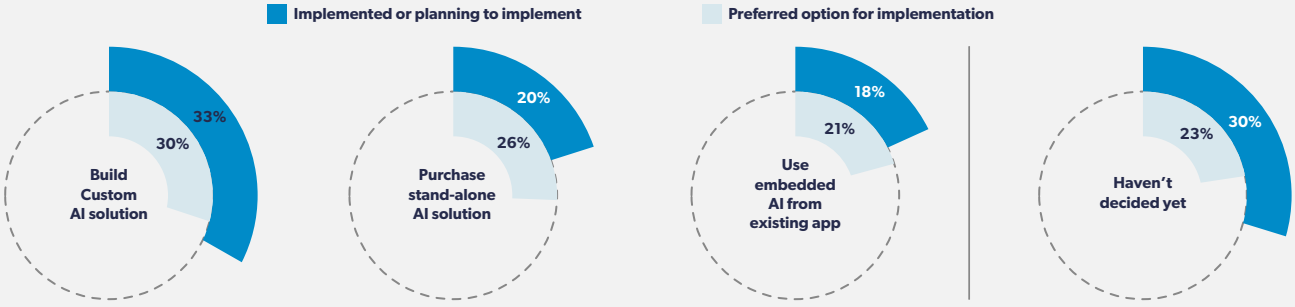
## Deployment strategies vary – a 'hybrid' approach is common

Among companies implementing or planning to implement AI, deployment strategies are split fairly evenly, between 'buy' and 'build', and in a state of flux. Nearly a quarter of companies have yet to determine a preferred approach (fig. 34).

**"We learned that a 'half-way house' – suppliers, plus in-house work – is best."**

**Chief Digital Officer, UK transport company**

**Fig.34. Preferred AI implementation approach by end-user organisations**



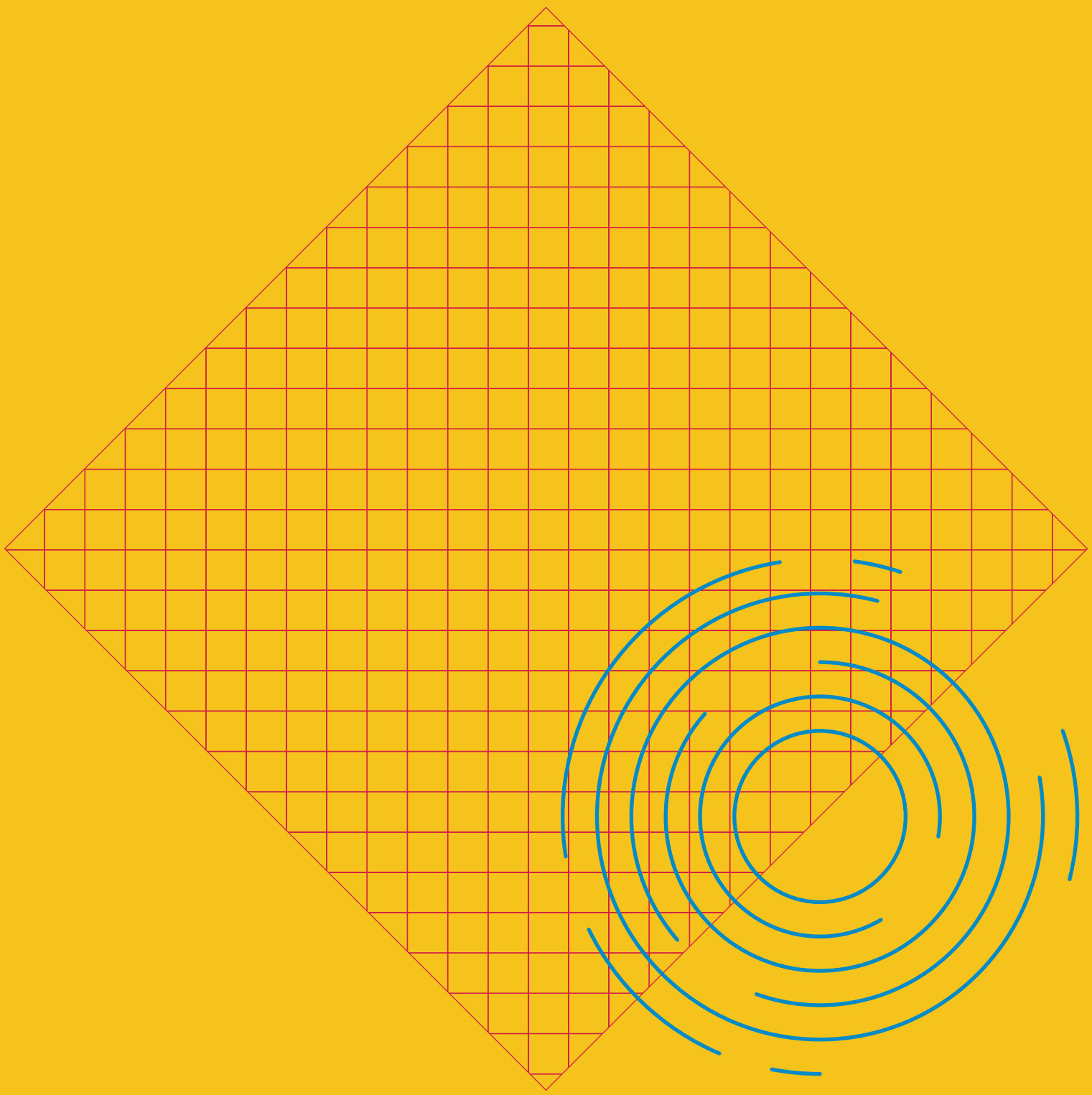

Base: Implemented or planning to implement, n = 80; Preferred option for implementation, n = 81, Gartner Research Circle Members; excludes "Not sure".
Question: For the most part, how has your organisation implemented or is planning to implement this artificial intelligence solution? And what is the preferred option for the implementation?
*Source: Gartner (August 2017) – Survey Analysis - Enterprises Dipping Toes Into AI but Are Hindered by Skills Gap (Fig. 3).

Nearly a third of mid-size to large organisations report that their preference is to build custom AI solutions. A desire for customisation, control, skills development and learning drives these companies' planning strategies. "We probably need to get our hands around the technology and see what it can deliver for us" (Manager, UK infrastructure company).

Our conversations with buyers highlight that few expect to adopt a 'build' approach in isolation. Given skills shortages, and the opportunity for faster time-to-value, most large buyers anticipate a 'hybrid' approach in which they combine in-house development with solutions from third-party AI software and service companies. The proportion of small companies that seek to build custom AI solutions in-house will be low, given a lack of resources and in-house data science teams.

Over a quarter of organisations deploying AI today are purchasing standalone AI solutions to achieve their objectives (Gartner). "Bring in someone who has the expertise, knowledge and skill-set – and can hold a mirror up to the organisation." (Manager, UK energy company). "We want to get someone in who specialises in data and can unlock value." (Product Manager, global transport supplier). There is ample opportunity to do so. In the UK there are 400 early stage 'best of breed' software companies offering AI-first solutions to challenges in most business functions – and an accessible 'on-ramp' to AI (see Chapter 8). These companies offer AI-native products, skilled teams of AI specialists, implementation support for nervous buyers, and iteration at speed and low cost. Challenges, when engaging with early stage suppliers, include their limited scale and maturing product scalability and performance. While small and mid-size buyers are more inclined to use third-party software for all their data science initiatives, large companies who buy standalone AI solutions may combine their use with some in-house development – the 'hybrid' approach.

Just over a fifth of organisations prefer to take advantage of AI functionality added to their existing applications, over time, by traditional vendors. Doing so can ease integration requirements and limit the requirement for further investment. This approach poses three challenges. First, availability is uneven. While Salesforce, for example, is acquiring and developing AI functionality for the sales function, in other functions and some sectors (manufacturing and utilities) incumbents are less forthcoming. Second, many incumbents are moving slowly, offering functionality that is limited compared with new, best-of-breed vendors. Finally, companies adopting this approach can lack competitive advantage. By definition, peers will have access to the same capabilities.



# Chapter 7

# The growth of AI services

## Summary

- For every £1 spent on enterprise software, £3 is spent on IT services – consulting, system integration and outsourcing.
- IT service companies involved in AI – 'AI service' companies – assist buyers with AI initiatives ranging from reviews of AI strategy to chatbot implementations.
- A focal point for AI service activity is supporting buyers' rollout of analytics software that incorporates AI.
- As mid-size companies and enterprises experiment with AI, most plan to involve a third party AI service provider, fuelling growth in the AI services market.
- While early and modestly-sized today, the AI services market is poised for rapid growth. As buyers use AI to gain value from historic investments in data collection, we expect AI services to offer a multi-billion-dollar market opportunity by 2020.
- 'Convergence' and consolidation are reshaping the market. Software companies are developing service capabilities to support solution-selling, while service companies are developing and acquiring software assets to access client opportunities and reduce cost to serve.
- The delivery model for AI services is changing. Led by mid-market buyers, we expect a mix shift from traditional projects of fixed scope, to managed services delivered via the cloud, paid for on an ongoing basis.
- Competition for AI services work above the mid-market will be fierce. For large deals, global service firms will leverage their data and data science personnel. Mid-size deals will represent a second battleground, with mid-tier vendors competing with each other and vendors from above and below. For smaller deals, select boutiques offer buyers the right success factors – accessibility, flexibility and low cost – to achieve scale and mature into mid-size vendors.
- Specialisation is becoming a key success factor for competitive differentiation and defensibility. Increasingly, individual AI service providers are focusing their competencies on specific verticals, business functions or business sub-functions.

# Recommendations

## Executives

- AI service providers deliver strategies, technologies and implementations for a range of AI initiatives, from chatbots to analytics. Evaluate opportunities to catalyse time to value in AI by engaging with AI service providers.
- Effective service providers will focus on solving business problems, not AI technology for its own sake. Engage with companies that describe clearly how they can improve your key performance indicators, using technology as an enabler.
- Managed service deployments are coming of age. For AI-powered analytics, evaluate whether a third-party solution delivered via the cloud could provide an evolving capability, at lower cost and with better support, than a traditional time-and-materials engagement.
- Competition for large contracts is fierce. Negotiate robustly with multiple suppliers to maximise value.
- Make use of vendor specialisation. Identify vendors offering expertise and trained machine learning algorithms in your chosen business function and sector.

## Entrepreneurs

- Consider offering a managed service capability to take advantage of evolving buyer behaviour.
- Explore under-served AI service market segments. Competition for generic, large deals is intense.
- Evaluate a specialisation strategy to develop data network effects and competitive differentiation in a competitive market.
- Proactively explore M&A to avoid being left sub-scale in a consolidating market.

## Investors

- Evaluate opportunities for investment in AI services, given potential for strong growth in the market.
- Be cognisant of competitive dynamics and the risk of commoditisation in the market.
- Evaluate whether encouraging portfolio companies to specialise in certain sectors or business functions could support their defensibility.
- Given extensive market consolidation, create and identify opportunities to achieve scale through mergers and realise value through trade sales.

## Analytics is a focal point for AI services

For every £1 spent on enterprise software, £3 is spent on IT services – consulting, system integration and outsourcing. IT service companies involved in AI ('AI service' companies) assist mid-size buyers and enterprises with AI initiatives, ranging from reviews of AI strategy and chatbot implementations to deployments of analytics software enhanced with AI.

Most companies deploying AI today are focused on improving decision-making (see Chapter 6). A focal point for AI service companies' activity, therefore, is supporting the rollout of analytics software that incorporates AI – 'AI Analytics'. AI Analytics enables buyers to derive insight from enterprise data. AI Analytics frequently draws on:

- enterprise resource data, such as inventory and order management information, to derive business intelligence;
- data from business functions to improve performance – for example, analysis of marketing information to improve customer segmentation and churn prediction.

## AI buyers seek to involve AI service providers

As mid-size companies and enterprises experiment with AI, most plan to include at least an element of outsourcing to AI service providers to achieve their goals, fuelling growth in the AI services market.

Companies lack the AI skills to 'go it alone', seek experts to deliver early wins during test-and-learn cycles, and cannot re-deploy existing staff without slowing other initiatives.

In the next three years, most companies will involve third parties in their data science initiatives. Small and mid-size companies are inclined to outsource entire AI initiatives, given resource constraints and risks associated with hiring in-house data science teams. Large enterprises typically adopt a 'hybrid' approach, engaging with third-party providers while developing in-house data science capabilities.

## 'Convergence' and consolidation are reshaping the market

A powerful trend of 'convergence' is reshaping the market for AI services. Software providers are strengthening their service capabilities to enable broader, more successful deployments. Conversely, service companies are developing and acquiring technology assets, from tools to broad applications, to access client opportunities and reduce cost-to-serve.

**"We're 80% revenue from services, 20% from software licenses. But that won't give you the full picture since the products are super-critical."**

**Senior Executive, AI services company**

Service companies are acquiring technology assets as well as developing them. In 2015, consulting company McKinsey acquired advanced analytics companies 4Tree (price and promotion optimisation for consumer goods), VisualDoD (analytics for the defence industry) and QuantumBlack (analytics for organisational performance).

Further, we expect extensive consolidation in the AI services market. The market is fragmented. Participants range from global consulting companies and system integrators to 'best-of-breed' AI service boutiques and mid-size providers. Boutiques and mid-size specialists with high quality AI personnel and expertise in specific business functions or sectors will be attractive targets to global vendors. For smaller vendors this is a double-edged sword. Some will achieve attractive exits, while others will be left sub-scale in a consolidating market.

## We expect a shift towards managed services

The delivery model for AI services is changing. Most large AI service companies offer clients the option of either:

- a managed service – a cloud service whereby fees are paid monthly for ongoing access to a remotely hosted capability;
- a time and materials deployment – a project of defined specification, cost and length after which engagement ends.

**"I would prefer it on a subscription basis, certainly initially. In a subscription model, the tech always evolves."**

**Product manager, global equipment supplier**

To date, enterprise customers have preferred time and materials engagements. We estimate that less than 25% of AI service companies' revenue is derived from managed service deployments.

However, demand for managed services is increasing. We expect the proportion of managed service deployments to double in the medium term, comprising up to 50% of engagements. Mid-size companies, that are leading adoption of cloud services more broadly, are driving this trend. Smaller buyers taking their first steps with AI technology value the lower up-front cost, increased flexibility, ongoing support, and regular technology updates that managed service deployments provide.

## Competition above the mid-market will be fierce

Despite the nascent stage of the AI services market, competition for large and mid-size contracts will be fierce.

Global system integrators, consulting companies and professional service firms that compete for today's largest general analytics contracts (£10m to £100m, or more, per year) are repositioning for strength in AI. Companies including Accenture, Atos, CapGemini, Cognizant, Deloitte, EY, IBM, Infosys, KPMG, McKinsey, Palantir, PwC, TCS and Wipro have developed multi-billion-dollar traditional analytics practices, typically with 5,000 to 15,000 in-house analytics professionals. However, on average less than 8% of the companies' analytics personnel are data scientists (MMC Ventures). Firms are investing heavily to increase the size of their data science teams but progress is uneven. We estimate an average of 1,200 data scientists per firm, but some have as few as 100. Speed will be important. Global vendors can collect larger customer data sets than smaller competitors. Data offers a network effect – more data enables better algorithms, whose improved results attract more customers and data.

Some large vendors focus on board-level engagements and multi-year global transformation projects worth hundreds of millions of pounds. An increasing number, however, are engaging with buyers' IT groups and targeting smaller analytics projects worth £300,000 or more per year. These global vendors pose a growing competitive threat to mid-size providers.

While embracing the opportunities of AI, incumbent global service providers must consider a challenge. Automation will challenge business models that rely on charging clients for large numbers of personnel with limited experience. AI should enable actionable advice with fewer people, at lower cost.

Mid-size AI service providers including Mu Sigma, Fractal Analytics, BlueYonder, Cartesian and Opera Solutions have significant revenue, sizeable workforces and a presence in multiple territories and sectors. Early to market, with strong AI expertise and specialisation around specific sectors or business functions, mid-size providers compete effectively for AI service deals worth £150,000 to £1m, or more, per year. While positioned to benefit from the increasing adoption of AI services, they will face pressure from select global vendors moving down-market, and boutique vendors pressuring from below.

**While embracing the opportunities of AI, incumbent global service providers must consider a challenge. Automation will challenge business models that rely on charging clients for large numbers of personnel with limited experience. AI should enable actionable advice with fewer people, at lower cost.**

Given the early stage of AI adoption among buyers, there is an attractive opportunity for boutique AI service providers to capture smaller initial contracts, of under £150,000 per year, with mid-size buyers or larger companies taking their first steps in AI. There are numerous boutique vendors globally. While some are lifestyle businesses modest in scale, others have the ambition and capability to grow into mid-tier winners. Peak, a UK-based AI services provider, combines an AI technology platform with high quality data scientists to address this market opportunity. Our discussions with mid-size AI service buyers highlight their openness to working with smaller providers – and often a preference to do so. Boutiques offer a responsive relationship, specialisation in a business function, potentially stronger AI expertise and lower cost than large vendors.

While the boutiques' market for contracts under £150,000 per year is less contested, boutiques contend with limited marketing budgets that inhibit their presence. They may be left behind as competitors consolidate, and will face a challenging competitive environment if they move up-market. Further, as software companies from Google to Salesforce increase the AI in their software platforms and applications, the 'on-ramp' to AI will become ever-gentler – potentially lessening the need for small companies to engage third-party help.

### Specialisation is becoming a key success factor

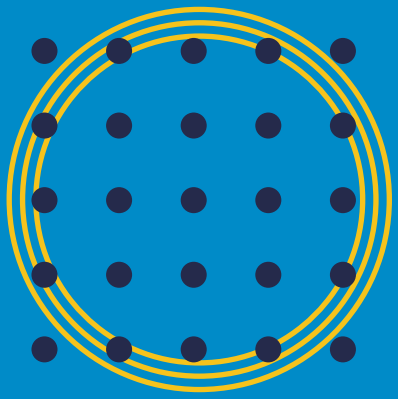
AI service providers are specialising – focusing their competencies on specific verticals (such as retail), business functions (marketing) or business sub-functions (customer segmentation).

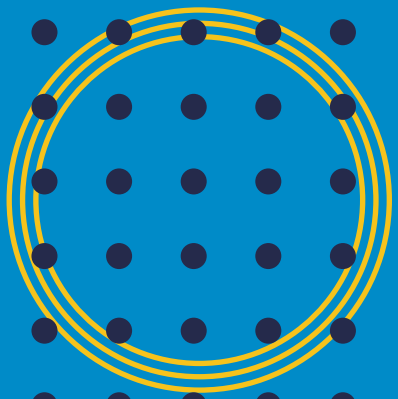
**"You become big by specialising."**

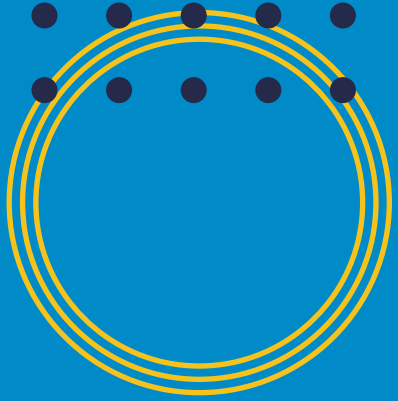
**Senior Executive, AI services company**

Large buyers value a supplier that offers specialisation. A specialised supplier offers: expertise in the customer's vertical or business challenge; large cross-customer data sets to optimise AI algorithms; and peer referenceability in the customer's vertical. In the short term, specialisation is becoming a success factor for companies to win market share among large enterprise customers. In the long term, buyers will demand greater specialisation as their in-house data science capabilities mature.

Smaller enterprises and mid-market customers that are experimenting with AI, seeking an 'on-ramp' to the technology, or have limited budgets typically prioritise other selection criteria. Smaller buyers value vendors that: rapidly address a tangible business problem to deliver ROI; provide a high touch service to guide buyers through 'test and learn' phases; offer geographic proximity; provide flexible pricing for initial deployments; and can integrate easily with existing IT systems to extract and process data.







# Chapter 8

# The dynamics of UK AI

## Summary

- There are nearly 400 independent, early stage software companies in the UK with AI at the heart of their value proposition.
- Over 80% of UK AI startups are vertically-focused business-to-business (B2B) suppliers. Few companies sell direct-to-consumer given the difficulty of acquiring training data from a 'cold start' and the deployment of AI by global consumer technology companies.
- Entrepreneurial activity in AI is unevenly spread. More UK AI companies (one in seven) address the marketing & advertising function than any other. For companies with a sector focus, finance dominates. In select sectors (manufacturing) and business functions (finance), activity appears modest relative to market opportunities.
- Few (one in ten) UK AI startups focus on developing core AI technologies applicable to a wide variety of markets. Among these companies, most focus on research into autonomous systems.
- AI entrepreneurship is thriving. The number of AI companies founded annually in the UK has doubled since 2014. A new UK AI company has been founded every five days, on average, since 2014.
- UK AI companies comprise nearly half the European total. AI is well represented in the UK, with a slightly higher proportion of startups focused on AI than in Europe (excluding the UK) or the US.
- UK AI companies are nascent. Two thirds of companies are in the earliest stages of their journey, with Seed or Angel funding. The sector, however, is maturing rapidly. UK companies are less embryonic than their European counterparts, offering competitive advantage in procurements.
- Over 40% of companies we meet have yet to receive recurring revenue. The journey to monetisation for AI companies can be longer given technical challenges, long sales cycles in a B2B-driven market, and client integration requirements.
- Globally, investments into early stage AI firms are typically 20%-50% larger than capital infusions into general software companies of comparable stages.
- Staging of capital into UK AI companies can be atypical. One in three growth stage companies raised a significantly larger post-Angel rounds than is typical.
- We feature eleven leading B2B and B2C AI companies across a range of sectors to illustrate how early stage AI companies are using AI to address opportunities.

# Recommendations

## Executives

- Explore the rich ecosystem of early stage AI companies in the UK. Most will be B2B vendors and some will offer market-leading solutions to challenges in your organisation.
- Identify potential suppliers and partners in your sector and in key business functions.
- Anticipate that many AI companies will be nascent, which may limit their ability to provide customer references and extensive resources.

## Entrepreneurs

- Identify potential competitors and partners using our market map.
- AI entrepreneurship has accelerated, increasing the number of market entrants and competition. Prioritise customer acquisition in an increasingly crowded market.
- Most UK AI companies are nascent. If you are a later stage company, leverage product maturity, customer referenceability and capital to secure competitive advantage. If you are an early stage company, prioritise adaptability and speed of execution.
- Implement technologies that can reduce the cost and time required to ingest data, process data and deploy your product at client sites, to overcome challenging go-to-market dynamics that are common for early stage AI companies.
- The journey to monetisation for AI companies can be longer, given technical challenges and B2B market dynamics. Adequately capitalise your business to withstand this, and to maximise your pace of customer acquisition which will enable you to lock in data network effects.
- Recognise that capital raises for early stage AI companies are typically larger than for non-AI software companies. Capitalise your business adequately to create and maintain competitive advantage.

## Investors

- With some segments over-supplied by startups and others under-served, identify attractive pockets of opportunity aligned with themes on which you focus.
- Use the market map and related data to evaluate the context of prospects (including competitors and volume of new entrants) and to anticipate market dynamics.
- With investments into AI companies larger than average, valuations can be elevated. Consider whether or not you are willing to 'overpay' to access opportunities.
- A significant proportion of AI companies have yet to achieve recurring revenue. Further, a sizeable minority of Angel stage companies are raising larger second rounds than is typical. Evaluate whether you are willing to invest in pre- or low revenue companies to secure access.

**With every paradigm shift in technology, innovative early stage companies emerge to improve and then reimagine business processes and consumer applications.**

## There are 400 early stage AI software companies in the UK

With every paradigm shift in technology, innovative early stage companies emerge to improve and then reimagine business processes and consumer applications. There are nearly 400 early stage, privately held AI software companies in the UK.

Over time, the distinction between 'AI companies' and other software providers will blur and then disappear as AI is applied to most business processes and sectors. Today, however, it is possible to highlight a sub-set of early stage software companies that have AI at the heart of their value proposition.

The market map, overleaf, places the 400 companies according to:

**Purpose:** Does the company focus on a business function (for example, marketing or human resources), a sector (healthcare, education) or core AI technology with cross-domain application?

**Customer:** Does the company predominantly sell to other businesses (B2B) or to consumers (B2C)?

**Funding:** How much funding has the company disclosed to date? We categorise companies as: Angel or Seed stage (under $500,000 to $2m); or Early or Growth stage (over $2m to c. $200m).

# UK AI Landscape (Early stage companies)

## Core Technologies

### AI INFRASTRUCTURE

EARLY STAGE / GROWTH

Grakn Labs, Graphcore, Hadean

ANGEL / SEED

Brytlyt, Memgraph, Seldon

### AUTONOMOUS SYSTEMS

EARLY STAGE / GROWTH

FiveAI, Oxbotica, Sky-Futures

ANGEL / SEED

Academy of Robotics, Accelerated Dynamics, Baro Vehicles, Drone Space AI, Evolve Dynamics, Intelligent Robots, Machines With Vision, Predina, React AI, Robik.ai

### COMPUTER V

EARLY STAGE / GROWTH

Neurence, Spect

ANGEL / SEED

Blue Vision Labs, Xihelm

## Sectors

### AGRICULTURE

EARLY STAGE / GROWTH

ANGEL / SEED

Dogtooth Technologies, Global Surface Intelligence, KisanHub, Hummingbird Technologies, Observe, Optimal Labs

### EDUCATION

EARLY STAGE / GROWTH

BridgeU, Century

ANGEL / SEED

Kwiziq, Oxademy, Synap

### FINANCE

EARLY STAGE / GROWTH

Aire, Arkera, BMLL Technologies, Cleo AI, Cytora, Digital Contact, Vortexa

ANGEL / SEED

Abaka, Acuity Trading, AlgoDynamix, Almax Analytics, Alpha I, Brolly, Chip, DealX, ForwardLane, FriendlyScore, Hello Soda, Knowsis, Metafused, Multiply, Oseven Telematics, ProvidensAI, RightIndem, Silicon Investing, Spixii, Torafugu Tech, TradeRiser, TradeTeq

### HEALTHCARE

EARLY STAGE / GROWTH

Babylon Health, BenevolentAI, BioBeats, BrainWaveBank, Cambridge Medical Robotics, Deontics, Desktop Genetics, Drayson Technologies, Healx, Ieso Digital Health, Kheiron, Snap40, Synthace, Your.MD

ANGEL / SEED

Aequa Science, Exscientia, InnersightLabs, InsideDNA, Kaido, Kraydel, LabGenius, Optellum, PetaGene, Resurgo Genetics, Sime Diagnostics, ThinkSono, Transformative, Visulytix, Viz

### INFRASTRUCTURE

EARLY STAGE / GROWTH

Li Clinithink

ANGEL / SEED

Alchera Technologies, Archangel Imaging, Biscuit, Calipsa, Crowd Connected, Disperse.io, Green Running, Grid Edge, NumberEight, OpenCapacity, TravelAI

### LAW

EARLY STAGE / GROWTH

Luminance

ANGEL / SEED

Cognitiv+, Eigen Technologies, ThoughtRiver

### MANUFACTURI

EARLY STAGE / GROWTH

CloudNC, Senseye

ANGEL / SEED

Flexciton, Materialize.X, Thingtrax

## Functions

### BI & ANALYTICS

EARLY STAGE / GROWTH

Black Swan Data, Brandwatch, Import.Io, Logical Glue, Massive Analytic, Peak, Rezatec, Ripjar, Satalia, Semantic Evolution, Signal Media

ANGEL / SEED

10x, Airfinity, Algo Digital Solutions, Amplyfi, Analytics Intelligence, Bird.i, Chorus Intelligence, Data quarks, Flumes, Gyana, Hertzian, illumr, Kite Edge, Krzana, LiveMetrics.io, Oxford Semantic Technologies, Policy Radar, Reportbrain, SeeQuestor, Shouter, Simudyne, Singular Intelligence, Terrabotics

### COMPLIANCE

EARLY STAGE / GROWTH

AimBrain, Callsign, Checkrecipient, Exonar, iProov, Onfido

ANGEL / SEED

Anon AI, CoVi Analytics, Eyn, VChain Technology, WaymarkTech

### CUSTOMER SERVICE

EARLY STAGE / GROWTH

DigitalGenius, Gluru, Sentiment

ANGEL / SEED

Action.AI, Enterprise Bot, Humley, Hutoma, rasa, Sentient Machines, True AI

### HUMAN RESOURCES

EARLY STAGE / GROWTH

Beamery, Behavox, PredictiveHire, Qlearsite, Rotageek, Saberr, ThisWay Global

ANGEL / SEED

Cyra, Grad DNA, Headstart App, Human, MeVitae, Occupassion, Potentially, StatusToday, Unmind

### IT

EARLY STAGE / GROWTH

4th Office, Aria Networks, Aurora AI, Automated Intelligence, Celaton, Diffblue, Focal Point Positioning, Mettrr, Rainbird Technologies, Recordsure, Redsift, Speechmatics, Sumerian, Trint

ANGEL / SEED

Ampliphae, Automorph, Autto, BigHand, Capito Systems, Cardinality, Context Scout, Cyanapse, Digital Taxonomy, Fantoo, Fedr8, Firedrop, Fraim, Intelligent Voice, jClarity, Linguamatics, Mentat Innovations, MicroBlink, Retechnica, Rossum, Skipjaq, TextRazor, Thingful, Unity {Cloud}Ware

## Function – Marketing & Advertising

### ANALYTICS/OPTIMISATION

EARLY STAGE / GROWTH

Admedo, Decibel Insight, Fresh Relevance, Insider, Intent HQ, Jampp, LoopMe, Perfect Channel, Realeyes, Storystream, Twizoo

ANGEL / SEED

Advizzo, Aiden, Bibblio, Carsift, Chattermill, Concured, Creative AI, Crowdemotion, Crystal Apps, CustomSell, FindTheRipple, Incisively, Media IQ, Mercanto, Metageni, Mobile Acuity, Nudgr, Phrasee, Platform360, rais, re:infer, Sweet Pricing, Swogo, TUMRA, Vaix, Viewsy

### AUGMENTED CONTENT

EARLY STAGE / GROWTH

Blippar

ANGEL / SEED

BoomApp, Gamar, Selerio, Vyking

### PURCHASE DISCOV RECOMMENDATI

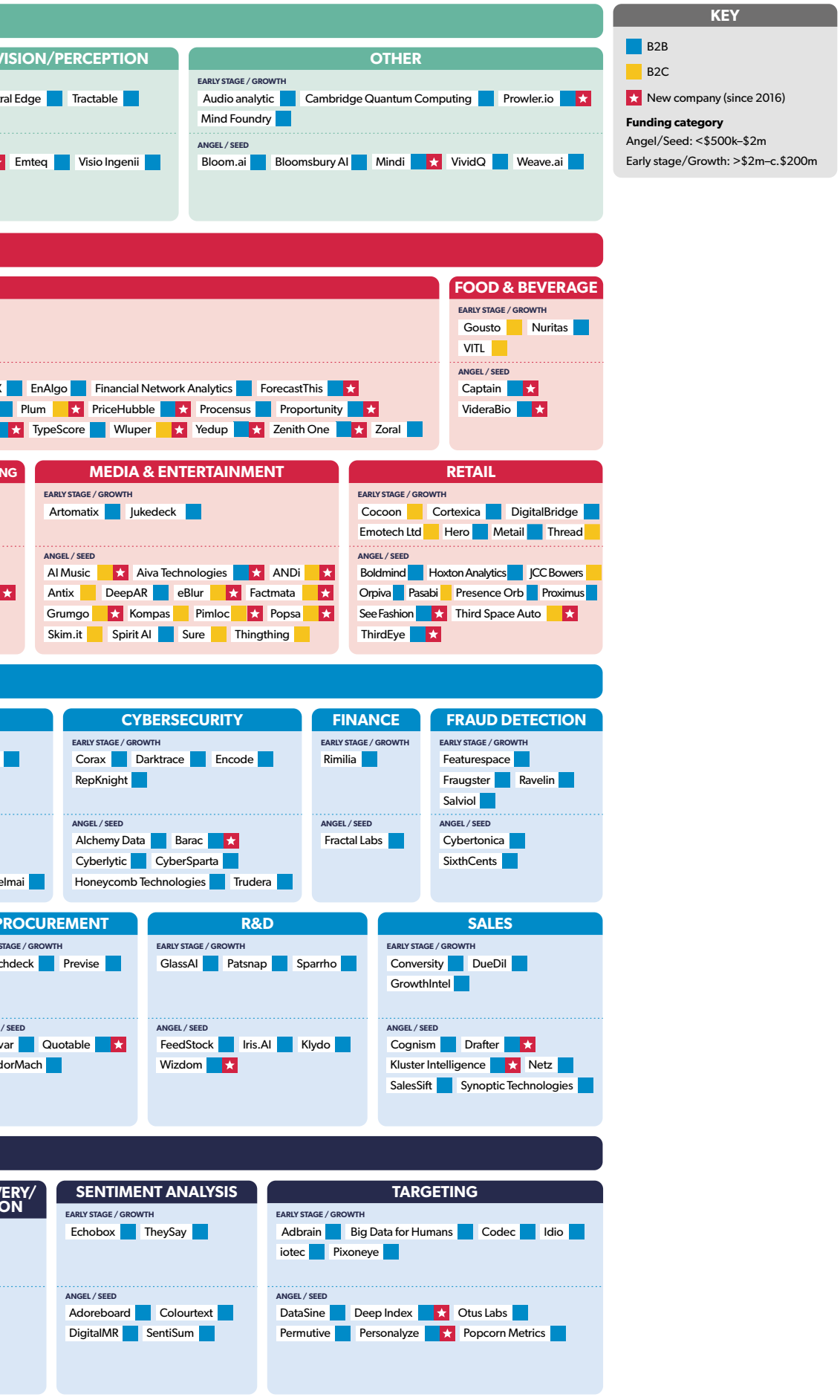
EARLY STAGE / GROWTH

Visii

ANGEL / SEED

Sources: MMC Ventures, Beauhurst, Crunchbase, Tracxn.

Additions or corrections? Email us at insights@mmcventures.com

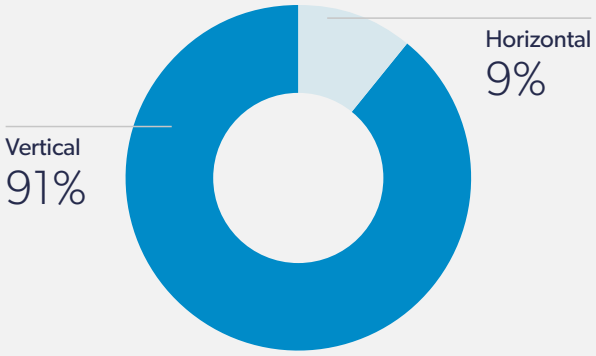

KEY
B2B
B2C
New company (since 2016)
Funding category
Angel/Seed: <$500k–$2m
Early stage/Growth: >$2m–c.$200m
VISION/PERCEPTION
ral Edge
Tractable
Emteq
Visio Ingenii
OTHER
EARLY STAGE / GROWTH
Audio analytic
Cambridge Quantum Computing
Prowler.io
Mind Foundry
ANGEL / SEED
Bloom.ai
Bloomsbury AI
Mindi
VividQ
Weave.ai
EnAlgo
Financial Network Analytics
ForecastThis
Plum
PriceHubble
Procensus
Proportunity
TypeScore
Wluper
Yedup
Zenith One
Zoral
FOOD & BEVERAGE
EARLY STAGE / GROWTH
Gousto
Nuritas
VITL
ANGEL / SEED
Captain
VideraBio
NG
MEDIA & ENTERTAINMENT
EARLY STAGE / GROWTH
Artomatix
Jukedeck
ANGEL / SEED
AI Music
Aiva Technologies
ANDi
Antix
DeepAR
eBlur
Factmata
Grumgo
Kompas
Pimloc
Popsa
Skim.it
Spirit AI
Sure
Thingthing
RETAIL
EARLY STAGE / GROWTH
Cocoon
Cortexica
DigitalBridge
Emotech Ltd
Hero
Metail
Thread
ANGEL / SEED
Boldmind
Hoxton Analytics
JCC Bowers
Orpiva
Pasabi
Presence Orb
Proximus
See Fashion
Third Space Auto
ThirdEye
CYBERSECURITY
EARLY STAGE / GROWTH
Corax
Darktrace
Encode
RepKnight
ANGEL / SEED
Alchemy Data
Barac
Cyberlytic
CyberSparta
Honeycomb Technologies
Trudera
FINANCE
EARLY STAGE / GROWTH
Rimilia
ANGEL / SEED
Fractal Labs
FRAUD DETECTION
EARLY STAGE / GROWTH
Featurespace
Fraugster
Ravelin
Salviol
ANGEL / SEED
Cybertonica
SixthCents
PROCUREMENT
R&D
EARLY STAGE / GROWTH
GlassAI
Patsnap
Sparrho
ANGEL / SEED
FeedStock
Iris.AI
Klydo
Wizdom
SALES
EARLY STAGE / GROWTH
Conversity
DueDil
GrowthIntel
ANGEL / SEED
Cognism
Drafter
Kluster Intelligence
Netz
SalesSift
Synoptic Technologies
SENTIMENT ANALYSIS
EARLY STAGE / GROWTH
Echobox
TheySay
ANGEL / SEED
Adoreboard
Colourtext
DigitalMR
SentiSum
TARGETING
EARLY STAGE / GROWTH
Adbrain
Big Data for Humans
Codec
Idio
iotec
Pixoneye
ANGEL / SEED
DataSine
Deep Index
Otus Labs
Permutive
Personalyze
Popcorn Metrics

## Most AI software startups are vertically-focused B2B vendors

Nine in ten early stage AI software companies in the UK are solving a problem in a specific business function or sector (fig.35). Just one in ten is developing a core AI technology – a capability, platform or set of algorithms – applicable across multiple domains.

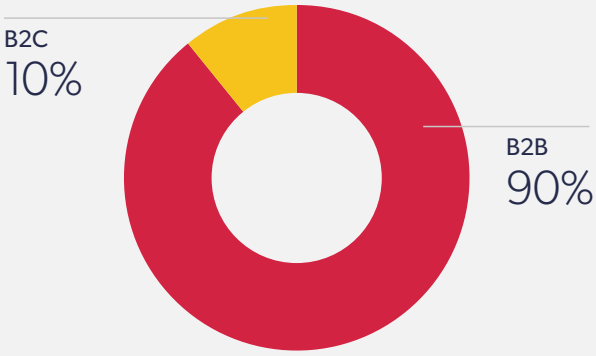
Further, nine in ten UK AI companies are predominantly B2B (fig.36), developing and selling solutions to other businesses. Just one in ten sells directly to consumers (B2C).

**Fig. 35. Nine in ten AI companies are application providers**




Source: Beauhurst, Crunchbase, Traxcn, MMC Ventures

**Fig. 36. Nine in ten AI companies are B2B**




Source: Beauhurst, Crunchbase, Traxcn, MMC Ventures

A 'cold start' challenge around data limits the number of new B2C AI companies. Training AI algorithms typically requires large volumes of data. While B2B companies can analyse the extensive data sets of the businesses they serve, in the absence of public or permissioned data (such as Facebook profile data), customer-facing companies usually begin without large volumes of consumer data to analyse. Typically, they deploy AI over time as their user bases and data sets grow.

Given the 'cold start' challenge, most consumers first experience AI via the world's most popular consumer applications – Facebook, Google, Amazon, Netflix, Pinterest and others – which leverage vast data sets and AI teams to deliver facial recognition, search and entertainment recommendations, translation capabilities and more using AI.

**Nine in ten early stage UK AI companies are applying AI to solve a problem in a specific business function or sector.**

## AI entrepreneurship is unevenly spread

More UK AI companies are addressing the marketing & advertising function (one in seven companies) than any others (fig.37). Of companies with a sector focus, finance (more than one in ten UK AI companies) and healthcare companies predominate (fig.38).

Activity is extensive within the general IT and BI & analytics buiness functions, and the retail and media & entertainment sectors.

**Fig. 37. UK AI companies (Business functions)**

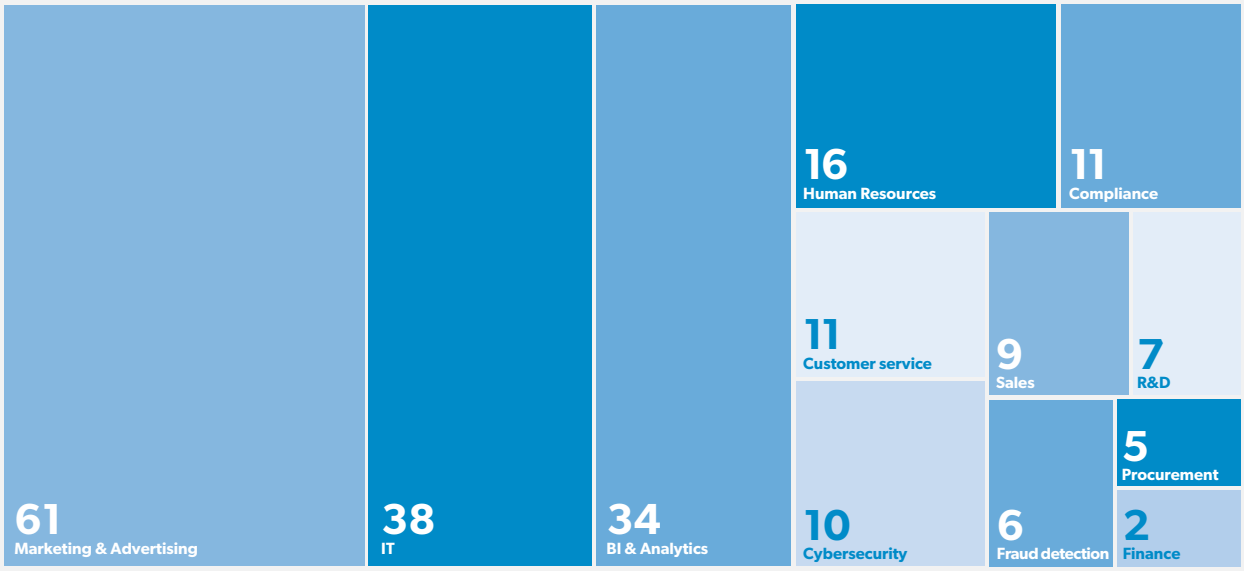
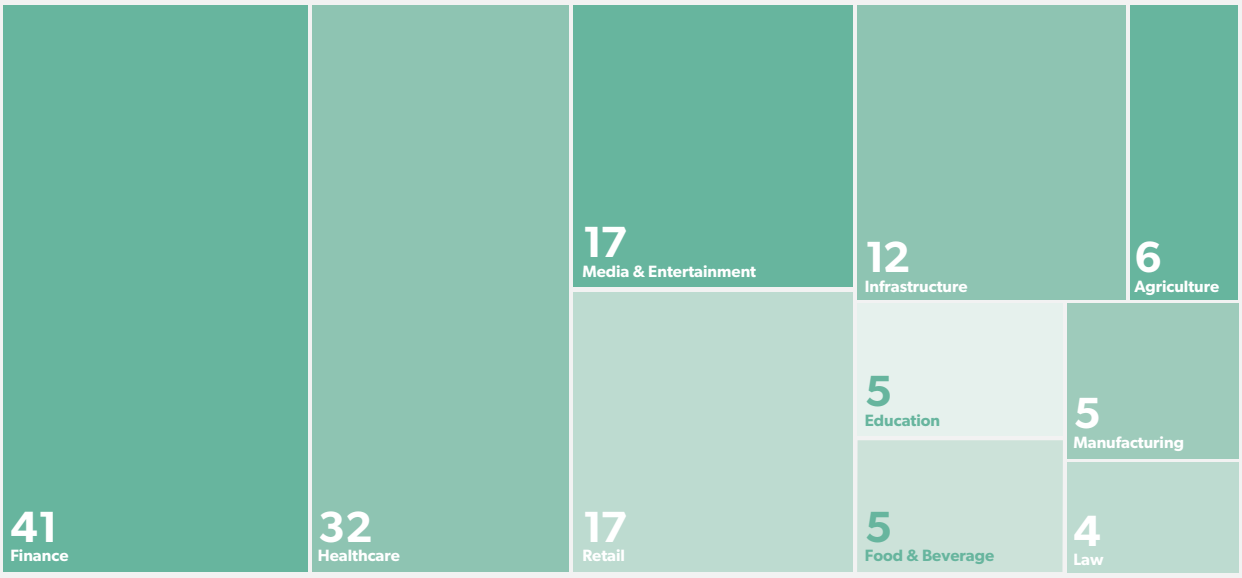



**Fig. 38. UK AI companies (Sectors)**




Source: Beauhurst, Crunchbase, Traxcn, MMC Ventures

Activity is these areas is high, in part, because they are attractively positioned to benefit from AI. All offer:

- numerous prediction and optimisation challenges well suited to the application of AI;
- the opportunity for significant, demonstrable value creation. In the finance sector, performance against a benchmark or reduced time-to-serve are measurable. In the marketing function, improved campaign conversion is quantifiable;
- large data sets for training and deployment, although access to data in healthcare can be a challenge;
- a path to better-than-human performance, through AI, that is technically achievable;
- alternatives to automation that are impractical (healthcare) or expensive (finance).

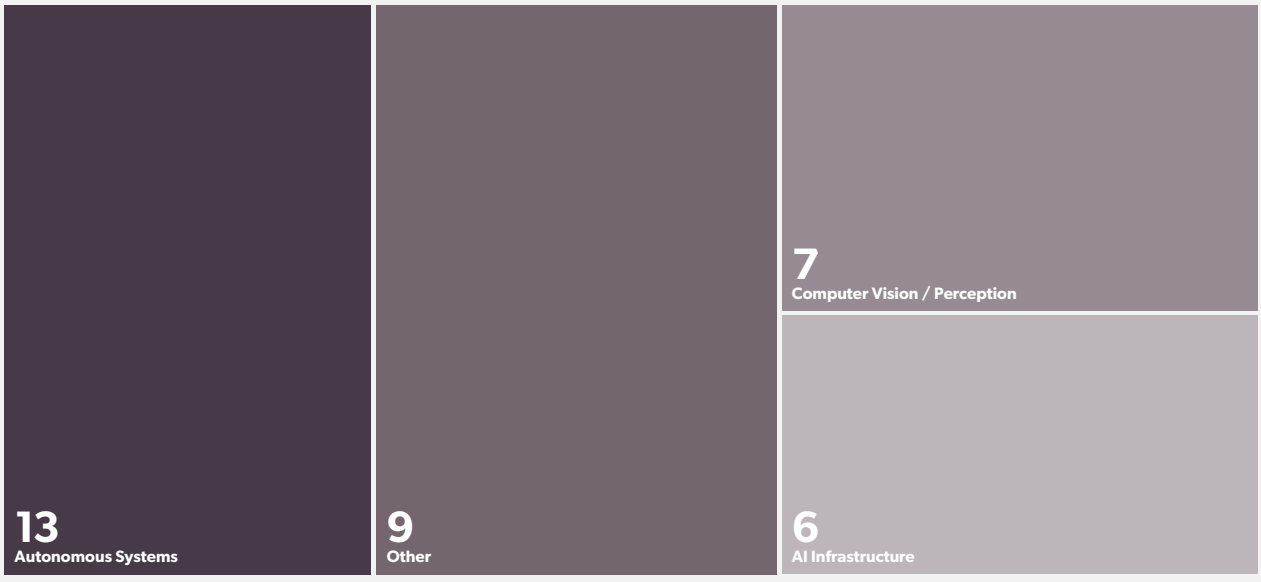
Modern marketing & advertising represents a sweet-spot for AI. Consumers have billions of touch points with websites and apps, which provide a rich seam of complex data that is difficult to analyse using rules-based software. Supplementary data sources, such as social media, can also be analysed at scale for the first time using natural language processing AI. Further, almost every stage of the marketing & advertising value chain is ripe for optimisation and automation,including: consumer segmentation; consumer targeting; programmatic advertising; consumer purchase discovery; and consumer sentiment analysis. Given significant opportunity, but extensive activity, competition and commoditisation are likely to be the primary challenges for early stage AI marketing & advertising companies.

In select areas, activity is modest relative to market opportunities. In manufacturing, few startups address a substantial need. Manufacturers' material costs could be reduced if analysis of product quality data were improved. Buffering (the storage of raw materials to compensate for unforeseen production inefficiencies) could be reduced by up to 30% with more predictable production. The requirement for significant domain expertise likely serves as an inhibitor to younger entrepreneurs in this area.

Opportunities in the finance function, and legal sector, are also greater than activity implies.

**In select areas, activity is modest relative to market opportunities. In Manufacturing, few startups address a substantial need.**

**Fig.39. UK AI companies (Core technologies)**



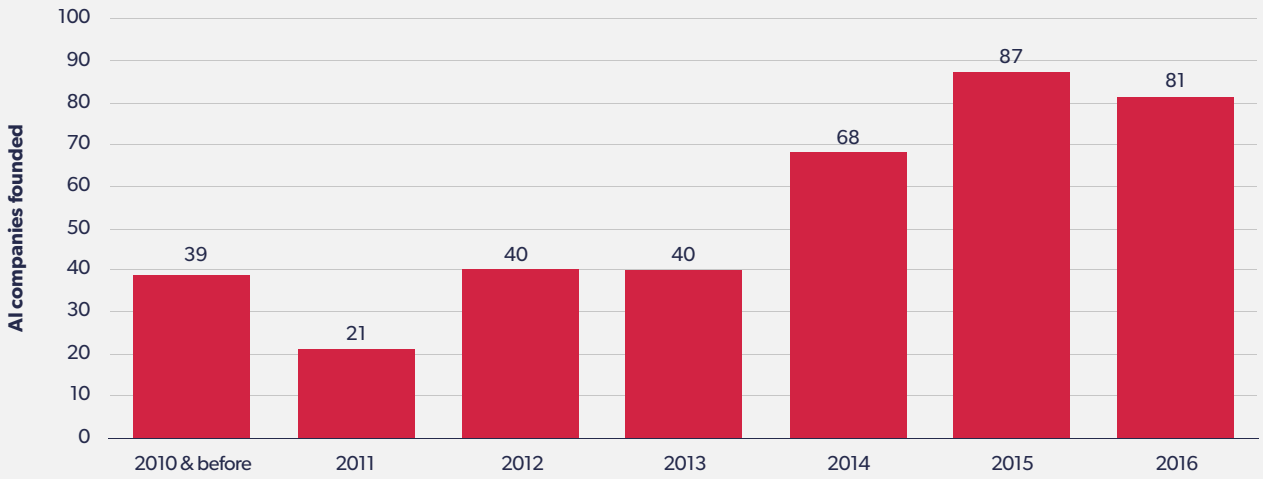

Source: Beauhurst, Crunchbase, Traxcn, MMC Ventures

One in ten UK AI startups develop core, 'deep tech' solutions applicable to a wide variety of markets, instead of applications for specific business functions or sectors. Among these companies, activity is greatest in the field of autonomous systems (fig. 39). Entrepreneurs are addressing a requirement for better independent decision-making – within autonomous cars, trucks, drones and industrial equipment. The technology can also be applied to overcome challenges relating to fleet management, vehicle pick-ups and drop-offs, and logistics networks. Solutions to these challenges are valuable as network models for transport (Uber), food delivery (Deliveroo) and other services gain adoption.

## AI entrepreneurship has doubled

The number of AI companies founded annually in the UK has doubled in recent years (2014–2016) compared with the prior period (2011–2013) (fig. 40). Two thirds of all UK AI companies have been founded since 2014. Since 2014, on average a new AI company has been founded in the UK every five days.

**Fig. 40. AI entrepreneurship has doubled since 2014**




Source: Beauhurst, Crunchbase, Traxcn, MMC Ventures

The number of AI startups is being fuelled by maturing AI technology and catalysts for AI entrepreneurship.

Technological seeds planted during the last 20 years of AI research are bearing fruit today. New algorithms are delivering more effective results. An exponential increase in the availability of training data has improved algorithms' predictive power. Additionally, the development of graphical processing units (GPUs) has reduced the time required to train artificial neural networks by as much as 90%.

Additional factors, however, are supporting AI entrepreneurship. Globally, venture capital investment in AI companies has increased five-fold since 2013 (CB Insights). The provision of AI infrastructure and services from Google, Amazon, Microsoft and IBM has reduced the difficulty and cost of deploying AI solutions. Further, the growth of open source software, particularly TensorFlow which provides a library of AI algorithms, has reduced barriers to involvement.

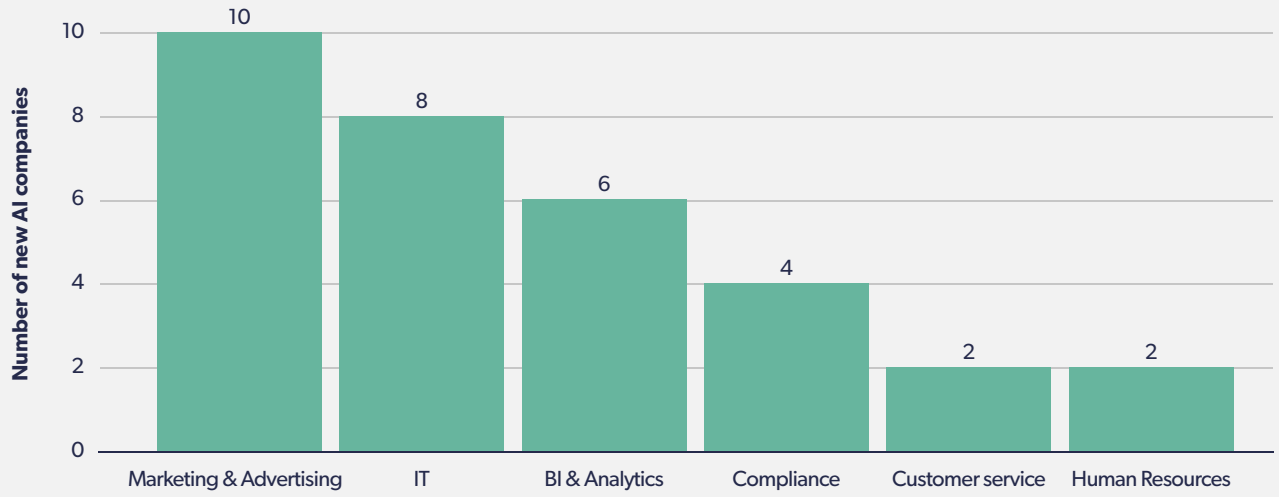
## Marketing & advertising, and finance, have experienced an influx of new entrants

From a significant base, the marketing & advertising function (fig.41) and the finance sector (fig.42) have experienced the largest number of new entrants from the beginning of 2016 to the present.

In areas with few early stage competitors, activity has increased significantly in the compliance function and the healthcare sector.

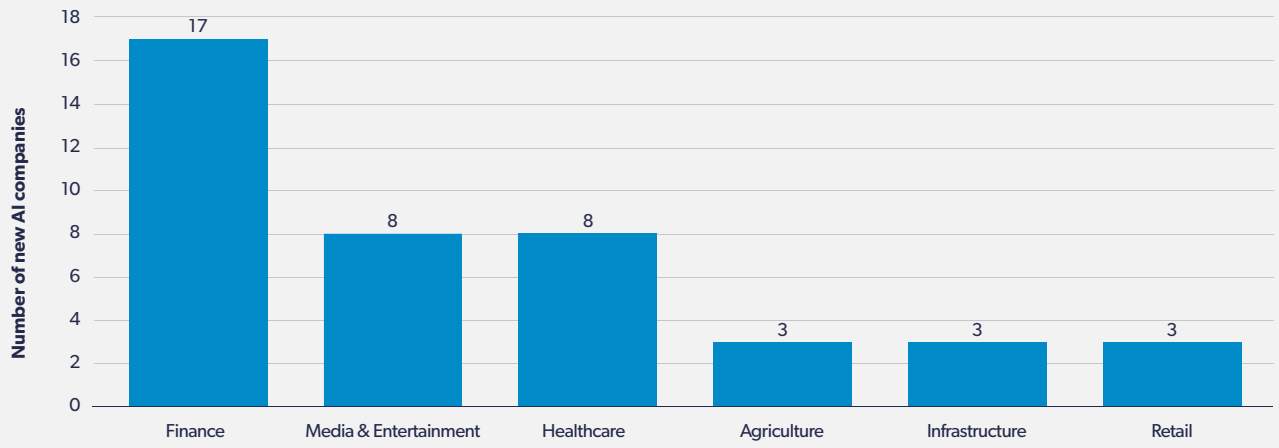
Opportunities in both areas are significant. Regarding compliance, JP Morgan Chase & Co increased related expenditure 50% between 2011 and 2015, to $9bn, employing an additional 19,000 staff (JPMorgan Chase & Co.). Citi, while reducing its global headcount 32% between 2008 and 2016, doubled its regulatory and compliance staff to 29,000 – over 13% of its workforce (Citi). Historically, in-house efforts by banks, concern regarding client concentration and competition from US companies may have limited new compliance startups in the UK, but activity and opportunities today are extensive.

**Fig. 41. The marketing & advertising function has the highest number of new AI companies**




Source: Beauhurst, Crunchbase, Traxcn, MMC Ventures

**Fig. 42. The finance sector has the highest number of new AI companies**

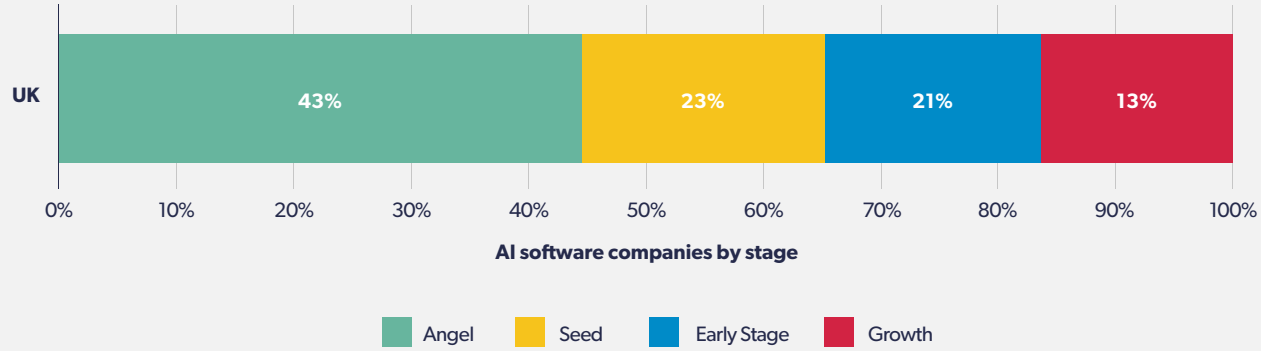



Source: Beauhurst, Crunchbase, Traxcn, MMC Ventures

## A nascent sector that is maturing rapidly

UK AI companies are nascent. Two thirds are at the earliest stages of their journey, with Seed or Angel funding (fig. 43). The sector is maturing rapidly, however, with nearly one in seven having received more mature, Growth-stage funding.

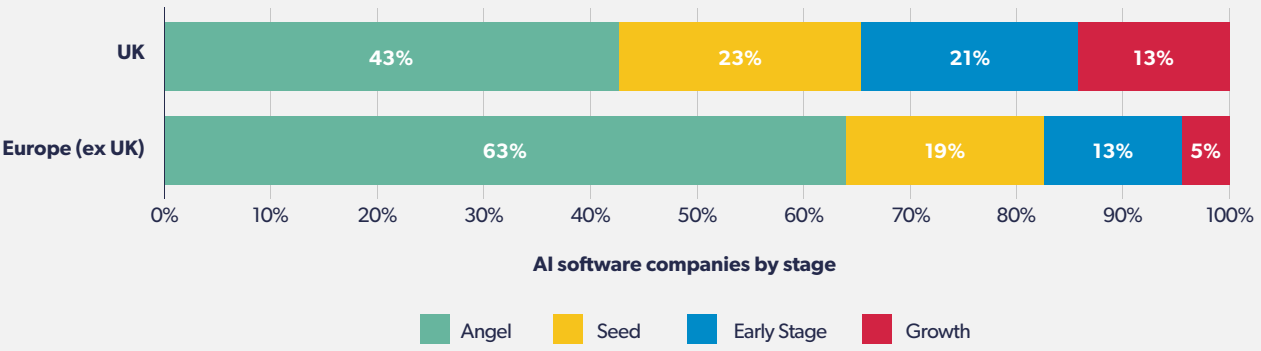
**Fig. 43. The UK AI sector is nascent**




Source: Beauhurst, Crunchbase, Tracxn, MMC Ventures

Relative to European counterparts, UK AI companies are less embryonic (fig. 44). The proportion of European companies at the earliest stages of their funding is 20 percentage points higher than in the UK. Further, the proportion of mature (Growth stage) European companies is less than half that of the UK.

**Fig. 44. European AI companies are highly embryonic**

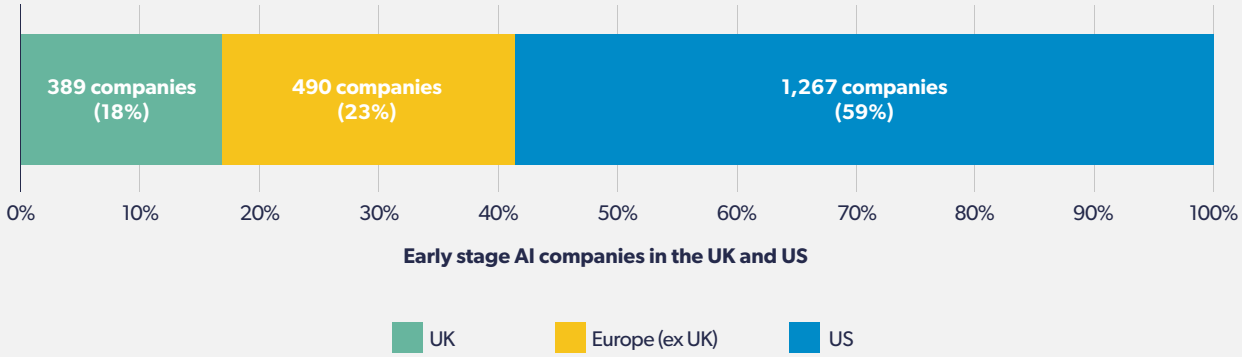



Source: Beauhurst, Crunchbase, Tracxn, MMC Ventures

## Half of Europe's AI companies are in the UK

The UK's 389 Angel to Growth stage AI software companies compete with approximately 490 in Europe (excluding the UK) and 1,267 in the US (fig. 45). Nearly half of all AI companies in Europe are in the UK.

**Fig. 45. UK AI comprises 18% of the European and US total**

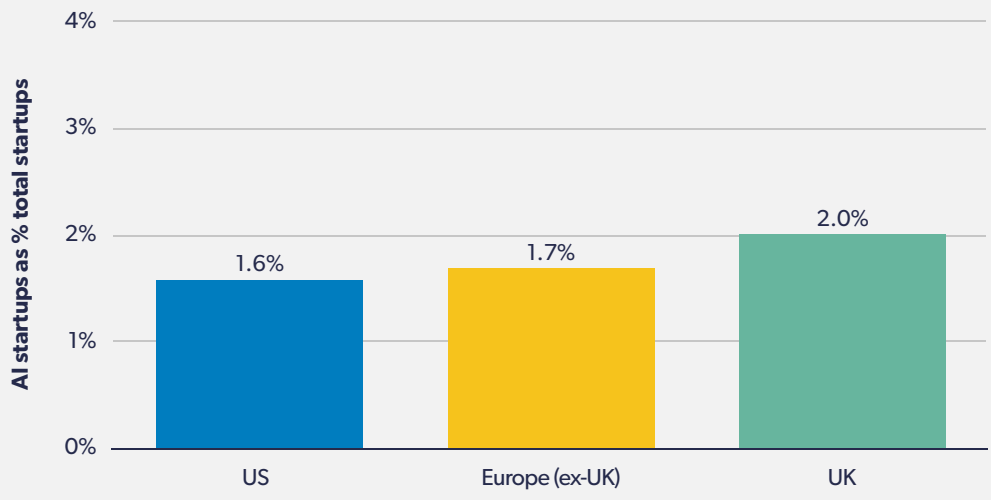



Source: Crunchbase, MMC Ventures

AI is well represented in the UK, where a slightly higher proportion of startups (2.0%) focus on AI than in the US (1.6%) or Europe ex-UK (1.7%) (Crunchbase) (fig. 46). The UK maintains valuable assets for strength in AI, including a quarter of the world's top 25 universities and a growing ecosystem of AI executives and investors following the acquisitions of Deep Mind, SwiftKey, Magic Pony and other UK AI companies. London also offers ready access to leading financial services customers.

The competitive environment will remain fierce, given the large number of AI startups in the US, richly funded US competitors, a broader US AI ecosystem and talent pool, and the potential impact of Brexit.

**Fig.46. A slightly higher proportion of UK startups focus on AI**

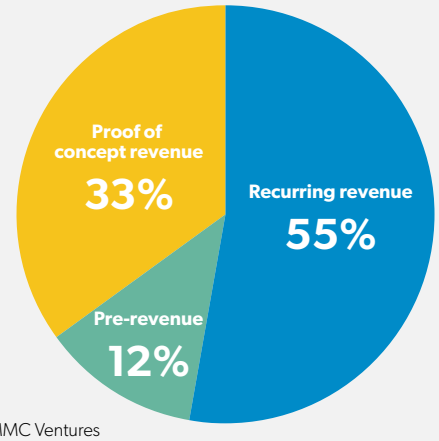



Source: Crunchbase, MMC Ventures

## The journey to monetisation can be longer

Over 40% of the UK AI companies we meet have yet to receive recurring revenue (fig.47). This is not solely a result of companies being 'early stage'. In a sample of 70 companies, the median profile is a company founded 3 years ago that has raised $2.0m.

**Fig. 47. Many companies have yet to receive recurring revenue**




Source: MMC Ventures

There is a perception, among some entrepreneurs in other fields and corporate executives, that most AI companies intend to be acquired for large sums of money while pre-revenue, instead of growing revenue by selling software and services. We believe this perception out of date, and based on an earlier, first wave of AI companies that developed core AI technology instead of vertical applications. All the AI companies we meet are implementing or developing monetisation plans.

AI companies can take longer to achieve significant monetisation because:

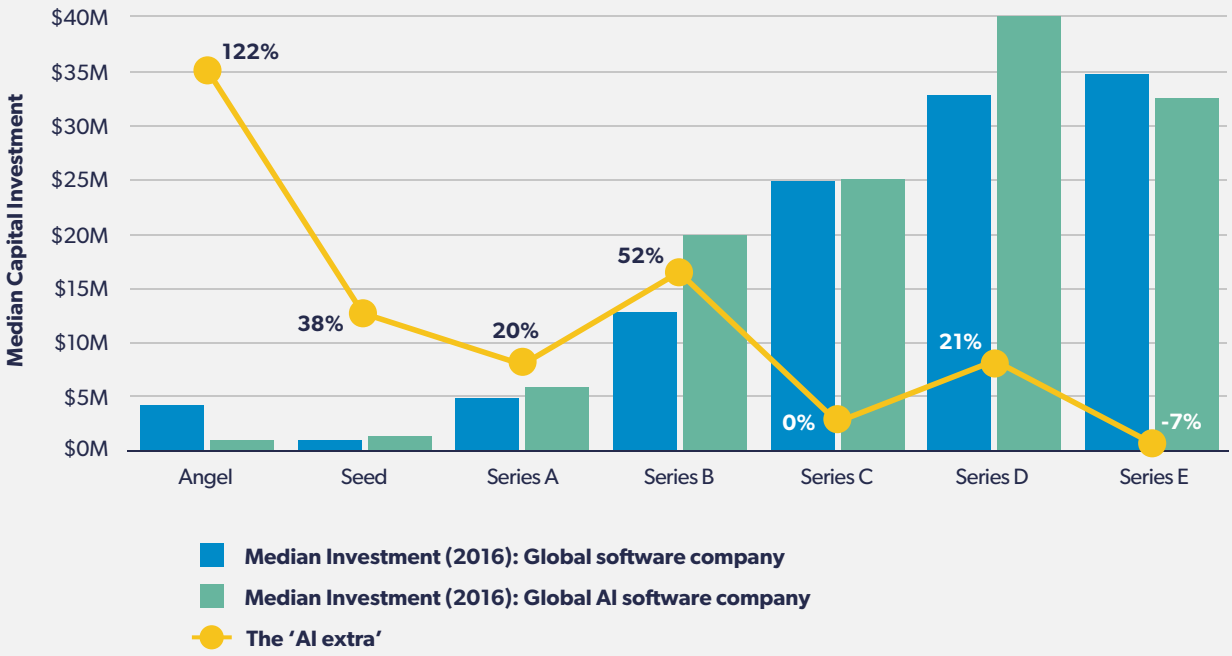
1. The bar to a minimum viable product in this technically challenging field can be higher, requiring longer development periods.
2. Companies may prioritise data acquisition ahead of revenue generation, to create defensibility through data network effects.
3. Over 90% of AI companies are B2B. The long sales cycles typical in B2B sales are exacerbated by many AI companies' focus on sectors, such as finance, with sensitive data sets and arduous procurement cycles.
4. Deployment periods can be lengthy given extensive data integration, data cleansing and product customisation requirements for each client. Many of the companies we meet monetise client integration and customisation work via project revenue.
5. A limited number of implementation personnel can inhibit growth. "We couldn't implement more sales even if we had them" (CEO, early stage UK AI company). In many early stage companies, that have small teams, one third of personnel are engaged in deployment support.

The longer path to monetisation poses a challenge to AI startups, particularly because expenditure can be higher due to the cost of AI talent. We recommend that AI companies raise sufficient capital to withstand this challenging period and to maximise go-to-market initiatives.

## Early stage AI companies are attracting larger investment rounds

Globally, investments in early stage AI firms are typically 20%-50% larger than capital infusions into general software companies at a comparable stage (fig. 48). This effect, while pronounced from the Angel to Series B stages, generally reduces and then disappears from the Series C stage and beyond. (Series D raises may be an exception, but the number of data points is modest).

**Fig. 48. Globally, early stage AI companies are raising larger rounds**




Source: Pitchbook

**Early stage AI companies are attracting larger funding rounds due to sector fundamentals and dynamics in the supply and demand of capital.**

Early stage AI companies are attracting larger funding rounds due to sector fundamentals and dynamics in the supply and demand of capital. AI companies' capital requirements can justify greater investment, given the longer development cycles to achieve a minimum viable product, the high cost of AI talent, and the larger teams required for complex deployments.

Beyond fundamentals, capital infusions are being inflated by extensive supply and limited demand. Many venture capitalists wish to invest in AI, and there are relatively few AI companies in which to invest. Globally, venture capital investment in early stage AI companies has increased ten-fold in five years, while the number of investable prospects remains limited.

**10x**

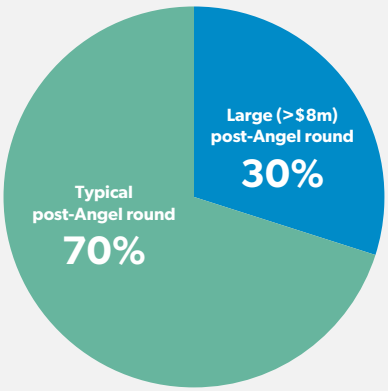
Globally, venture capital investment in early stage AI companies has increased ten-fold in five years.

Source: CB Insights

This dynamic is reflected in the UK, where staging of capital can be atypical. A sizeable minority of UK AI companies progress from their seed round to a larger raise than is typical for a subsequent round. One in three UK AI companies that raised more than $8m in a funding round had raised less than $1m previously (fig. 49).

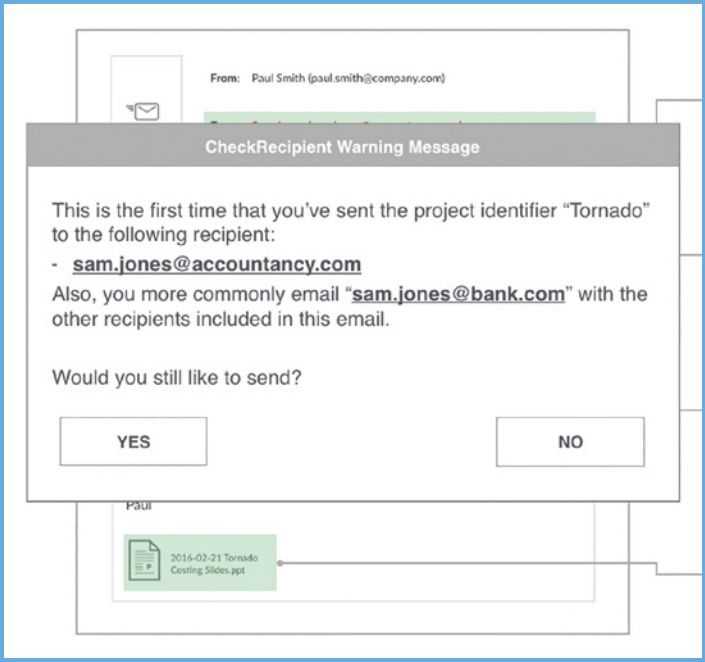
**One in three UK AI companies that raised more than $8m in a funding round had raised less than $1m previously.**

**Fig. 49. One in three UK AI companies raise large post-Angel rounds**




Source: Beauhurst, Crunchbase, Tracxn MMC Ventures

## Featured company




CheckRecipient

**Customers**

Businesses

**Function**

Compliance

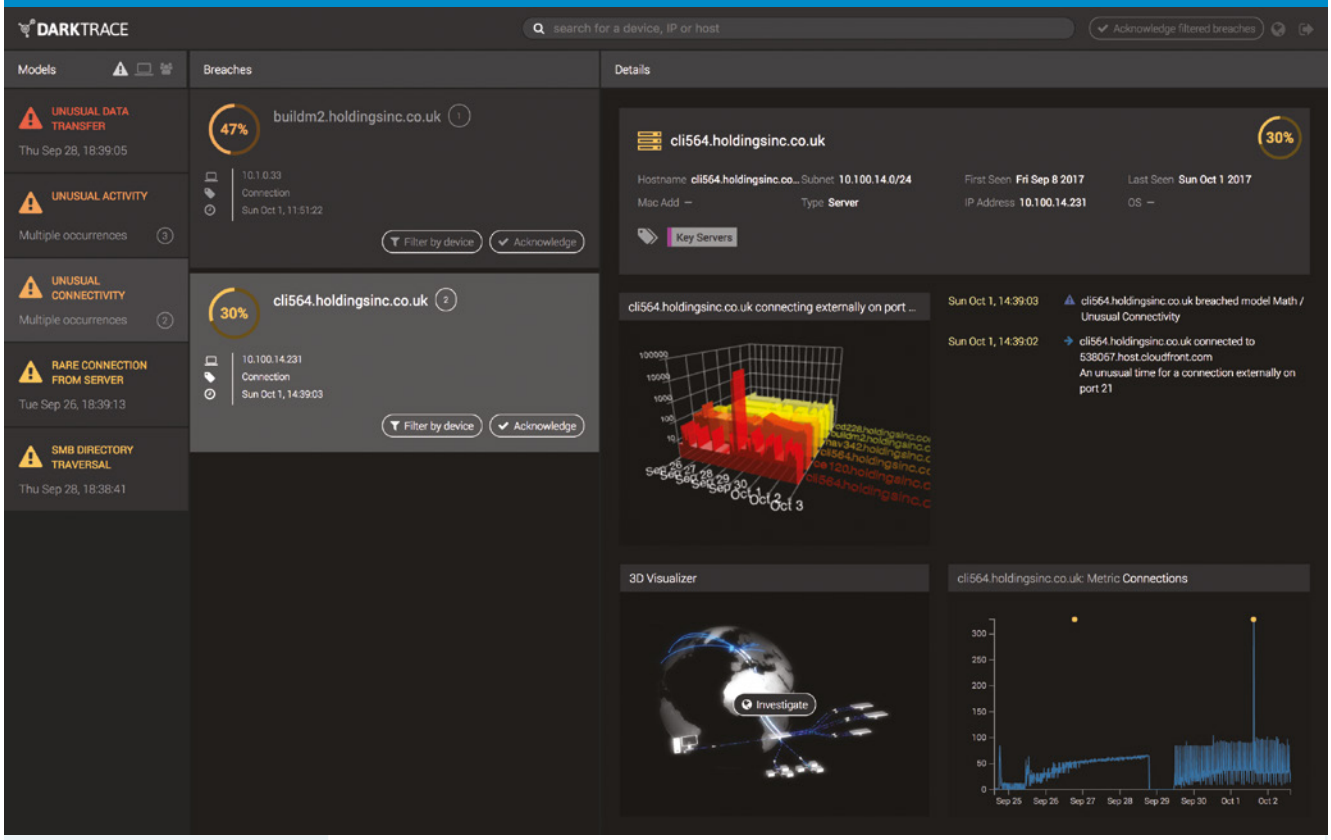
**How do you use AI to solve problems?**

"We're using machine learning to build a next-generation email security platform, to stop highly sensitive emails being sent to the wrong people. Misaddressed emails are the number one digital data security incident reported to the Information Commissioner's Office. Incumbent solutions rely on admin-heavy, rules-based approaches – or require significant user behaviour change.

We apply machine learning to historical email data, to understand conventional behaviour of users within an email network and their sending patterns. We can then detect deviations from these patterns and flag them. This automatically protects against data loss, without any administrative overhead or change in the way end users normally send emails."

Source: CheckRecipient

## Featured company




DARKTRACE

**Customers**

Businesses

**Function**

Cybersecurity

**How do you use AI to solve problems?**

"We use artificial intelligence to discover and respond to cyber-threats, which would otherwise have gone unnoticed, within organisations.

Our AI system is inspired by the principles of the human immune system. It can detect novel threats without prior knowledge of what is malicious. By learning what is 'normal' within a network, our technology identifies abnormal behaviour. With our technology, a threat can automatically and quickly be contained, giving a human security operator time to catch up.

Our AI was successful in defending against the WannaCry ransomware campaign that affected over 200,000 devices across 150 countries in May 2017. Our Enterprise Immune System solution not only detected the attack at its first signs, but also stopped it from spreading. It has also identified in-progress insider threats, hacks of connected devices (IoT), and other sophisticated cyber-attacks."

Source: Darktrace

## Featured company


# DigitalGenius

**Customers**

Businesses

**Function**

Customer Service

**How do you use AI to solve problems?**

"We use AI to automate the repetitive parts of the customer service workflow and deliver better customer experiences by making conversations more efficient in a range of channels – from email and chat to social media and mobile messaging.

Our Human+AI™ Customer Service Platform combines the best of human and machine intelligence to enable companies to exceed rising customer service expectations. We use deep learning algorithms to train neural networks on end-to-end historical customer service conversations. The AI converts words into sets of numbers and uses mathematical operations to extract meaning, context, and nuances of customer interactions. This enables the AI to deliver accurate prompts, offer automated replies and complete fields with correct data. With DigitalGenius, customer service agents focus on cases where human interaction and expertise are needed."

Source: DigitalGenius

## Featured company


gousto

**Customers**

Consumers

**Sector**

Food & Drink

**How do you use AI to solve problems?**

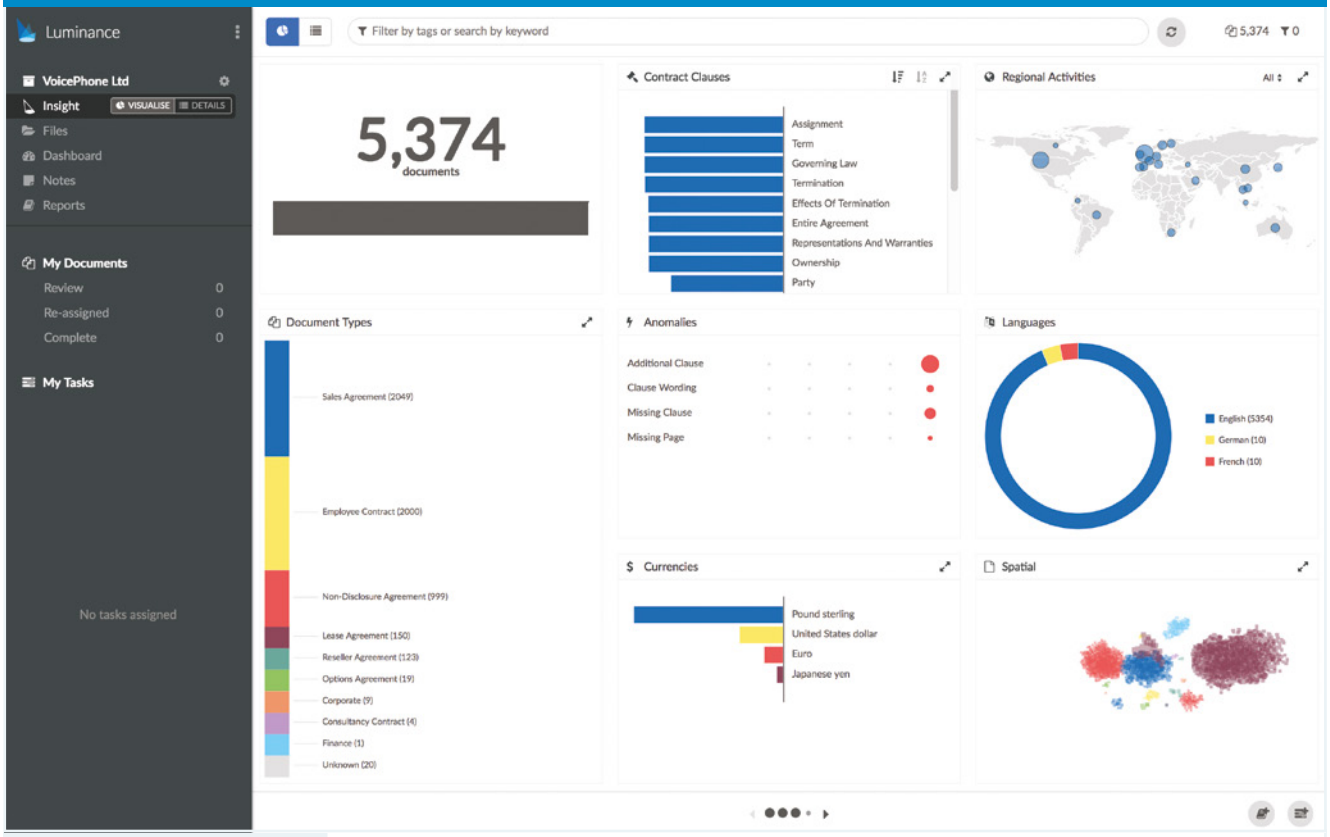
"We apply AI to provide huge improvements to customer experience. It's helped us to reduce food waste to nearly 0%, achieve record low error rates in packaging and delight customers with new recipes.

While supermarkets waste around 20% of food, we're significantly lower due to AI-powered probabilistic forecasting and optimisation, which enable just-in-time grocery operations.

To enhance customer experience, we've applied AI to our own recipe ontology (a knowledge database), which enables us to fully understand our recipes, compare new recipes to popular existing ones, and make recommendations to our customers efficiently."

Source: Gousto

## Featured company




Luminance

**Customers**

Businesses

**Sector**

Law

**How do you use AI to solve problems?**

"We use AI to offer an entirely new approach to legal document review. Our vision is to give lawyers instant, meaningful insight into vast bodies of documents, and enable AI to carry out low-level cognitive tasks on behalf of legal teams so that they can focus on higher value analysis. We provide lawyers with a plug-and-play tool to assist with the 'first pass' of document review, by intelligently sorting documents in order of likely priority with potential issues highlighted. Our initial use case is in document review for M&A due diligence and our customers have found efficiency gains of over 50% – vital in the fast-paced and competitive legal market. There are many other use cases for our technology, including insurance, compliance, property and in-house contract management.

Our technology, developed by our team of Cambridge University mathematicians, works by comparing thousands of legal documents simultaneously to detect patterns in their language using a unique combination of machine learning techniques. These patterns can be used to identify key information within documents – such as clause types, languages and locations – or to expose anomalies that may pose a risk to the project. Lawyers can focus and prioritise their review early in a project, while gaining additional insight through data visualisation."

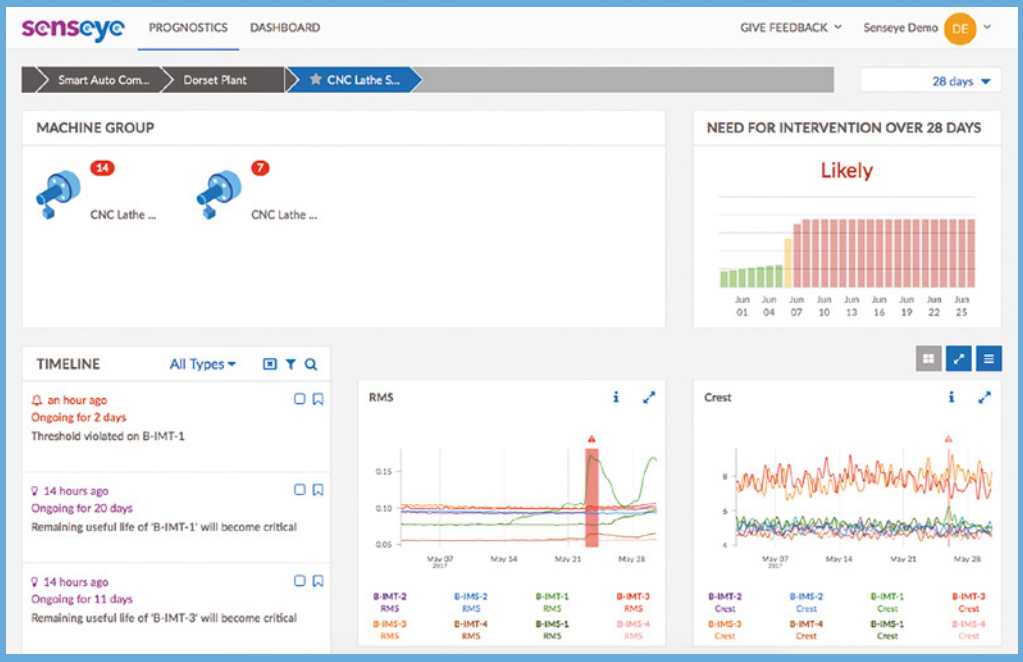
Source: Luminance

## Featured company

| | |
|---|---|
| **Customers** | Businesses |
| **Function** | Analytics |
| **How do you use AI to solve problems?** | "We enable our customers to use AI to grow their businesses. We deploy, for example, AI-powered predictive analytics for lead scoring, lead generation, churn prediction and up-sell estimation. All of these have a huge impact on a company's ability to grow revenues.<br><br>We've deployed demand forecasting algorithms that enabled companies to plan and meet demand more effectively. Our customers increased revenue, order fulfilment and customer satisfaction – while reducing inventory and transport costs. Through improved demand forecasting, for example, we've helped FTSE listed businesses free up millions of pounds of working capital and save on waste." |

Source: Peak

## Featured company




senseye

**Customers**

Businesses

**Sector**

Manufacturing

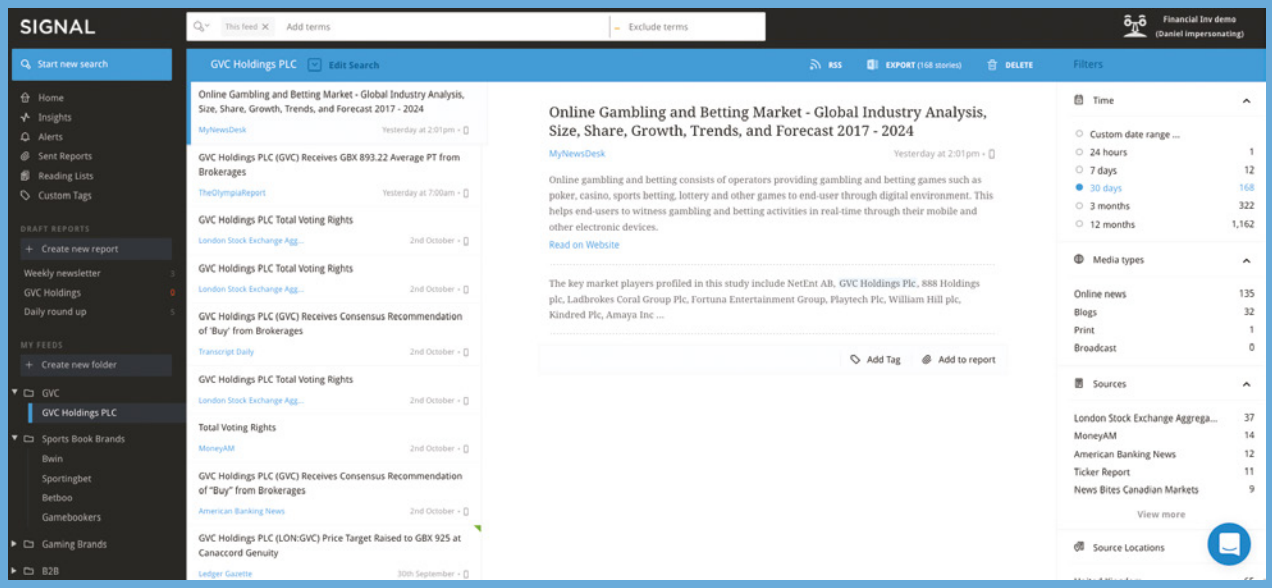
**How do you use AI to solve problems?**

"We enable manufacturers to perform predictive maintenance with much greater accuracy than has been possible before, preventing expensive unplanned downtime.

We use machine learning to improve and automate what condition-monitoring engineers have done manually in manufacturing organisations, at a scale far beyond human capability. We provide value from the data companies already have, but are not using effectively. This generates significant value in sectors that are margin sensitive or looking for competitive advantage."

Source: Senseye

## Featured company




SIGNAL

**Customers**

Businesses

**Function**

Analytics: Media Monitoring

**How do you use AI to solve problems?**

"We're using AI to transform how organisations use information to drive business impact. Our vision is to power informed decision-making everywhere. We have built a powerful AI engine that can monitor, analyse, extract insight and recommend actions to users in every key business function, from sales to strategy and public relations.

Our AI understands context and reads 2 billion articles in 2 seconds, offering hyper-relevant results in real-time and surfacing them in a simple-to-use platform. It also translates from over 40 languages - entirely for free."

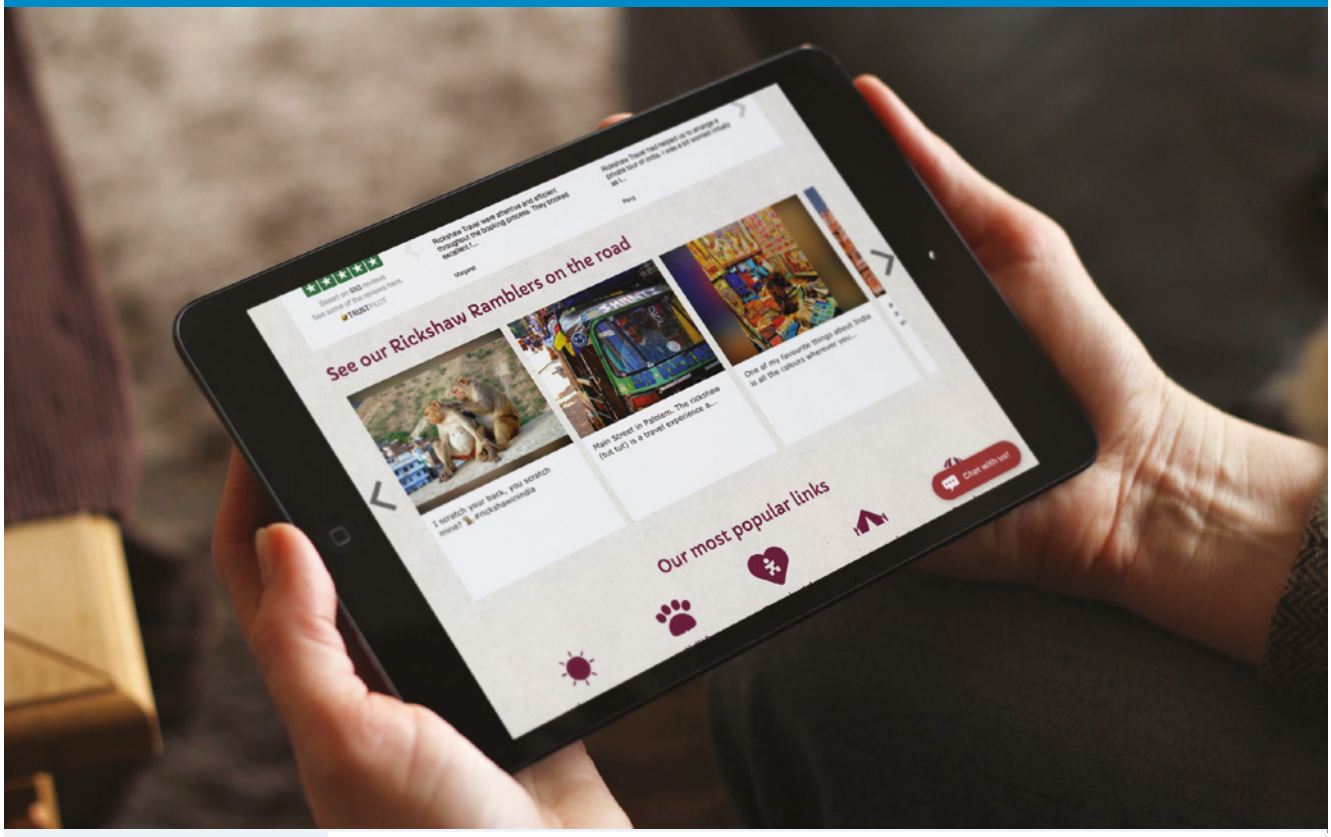
Source: Signal Media

## Featured company

| | |
|---|---|
| **Customers** | Hospitals |
| **Sector** | Healthcare |
| **How do you use AI to solve problems?** | "Our goal is to protect the health of every human being by bringing clinical attention to deteriorating health at the earliest possible point.<br><br>We operate in hospitals and in patients' homes, collecting real-time data and metrics from the patient using our own monitoring device. We monitor the patient with ICU-like accuracy, but without any leads or wires - the patient can go about their day, with snap40 at their side. We then take this huge volume of data and identify the patients that require physician or nurse attention. No physician or nurse can monitor data streams from hundreds of patients - that's where AI comes in. If we can bring medical attention to at-risk patients earlier, we can stop them deteriorating. We can enable patients to stay in their own homes, prevent the need for unnecessary hospitalisation, and save lives.<br><br>By allowing physicians, nurses and healthcare providers to scale up massively the number of patients they can manage in lower acuity environments, like patients' own homes, we also provide cost savings to providers – through fewer hospitalisations and reduced lengths of hospital stays." |

Source: Snap 40

## Featured company




STORY STREAM

CONTENT. ACCELERATED.

**Customers**

Businesses

**Function**

Marketing & Advertising

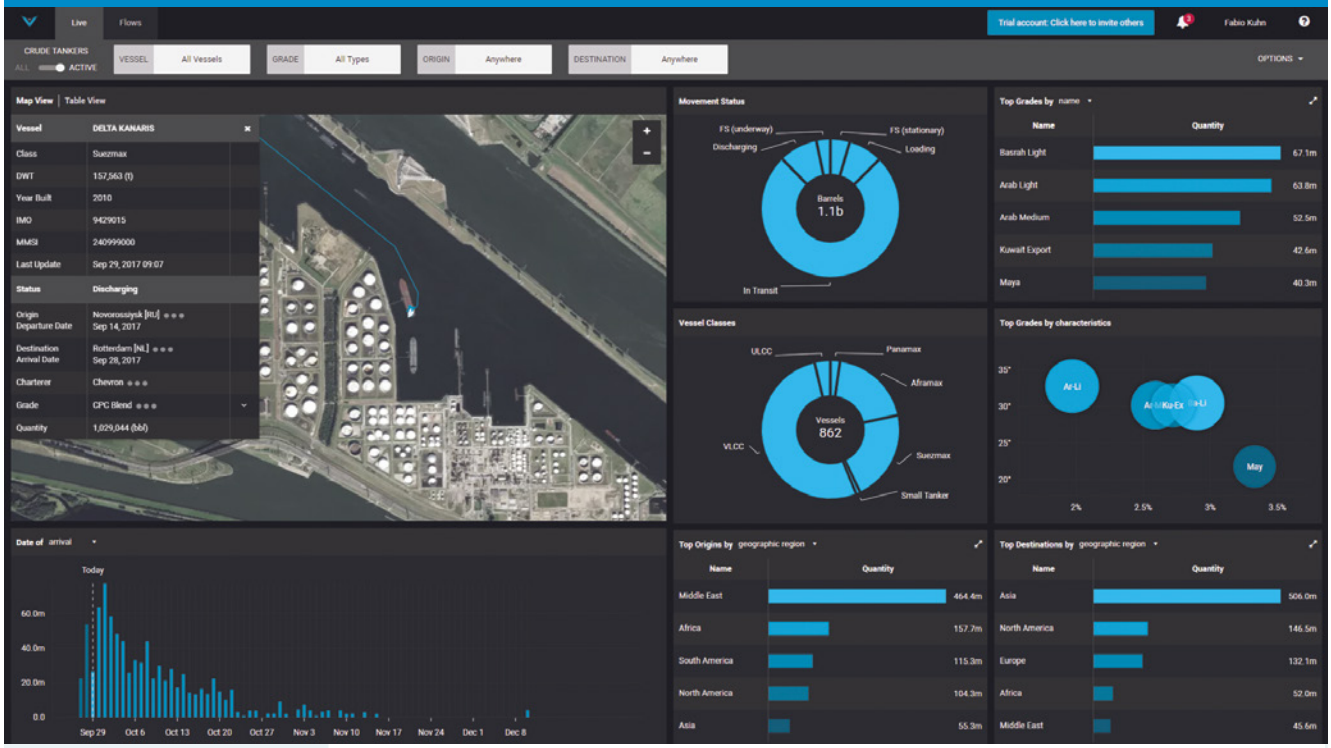
**How do you use AI to solve problems?**

"We help global brands transform the performance of their digital content to increase their marketing ROI. The complexity in understanding what content to create, how to manage and publish it at scale, and then show its ROI is a significant data problem – as the link between these factors is generally broken. AI offers a powerful way to connect and scale a brand's content operations by helping marketing teams more efficiently analyse, manage and distribute content – and show its ROI better than they have been able to do before.

We use custom-built deep learning algorithms to automatically tag and analyse content. We then match that content with consumer analysis to enable a more personalised and engaging brand experience."

Source: StoryStream

## Featured company




VORTEXA

**Customers**

Businesses

**Sector**

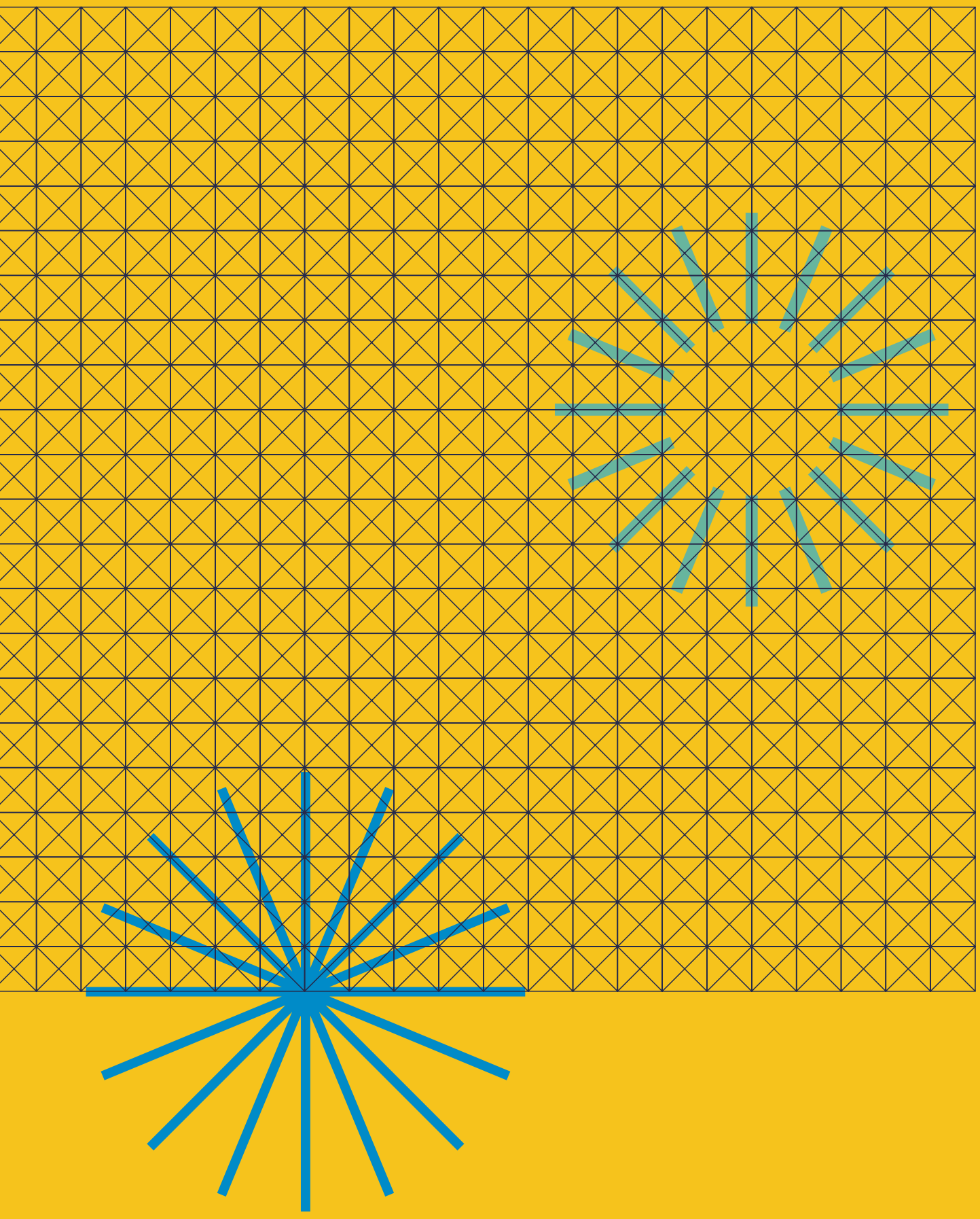
Energy

**How do you use AI to solve problems?**

"We use AI to help optimise the flow of energy on the planet. Energy is a $7 trillion industry which is directly linked to the prosperity of our society. Today, there is an immense gap in information between what happens in the physical world and what reaches the energy markets before decisions need to be made.

Vortexa uses machine learning algorithms to piece together an extremely large amount of complex and disparate data, particularly from new satellite constellations, to help us maximise the utility and value of our natural energy resources."

Source: Vortexa



# Chapter 9

# AI entrepreneurs' perspectives


## Summary

- Entrepreneurs anticipate a new, AI-driven future. AI will improve decision-making and increase automation in every sector and most businesses functions, with profound effects.
- Early stage companies offer buyers innovation and flexibility. Startups enable established companies to harness new technologies, and buyers can shape evolving propositions from early stage companies to their bespoke needs.
- When engaging with early stage companies, buyers can maximise value by adopting a collaborative mindset and simplifying procurement processes.
- Successful AI entrepreneurs deliver solutions, not technology. AI companies should focus on solving a business problem, not on technology as an end in itself. Identifying repetitive, data-intensive problems well suited to AI enables companies to attract clients and address inefficiencies in their own organisations.
- Access to data, scarce talent and difficult productisation processes are key challenges for early stage AI companies. Companies can mitigate these challenges, respectively, by implementing data acquisition strategies early in their journey, building relationships with academic institutions and research communities, and developing feedback loops between development teams and customer success functions.
- Key success factors for AI entrepreneurship are: customer focus; continuous technological evolution; development of data access strategies; long-term planning; and perseverance in this demanding field.

# Recommendations

## Executives

- Entrepreneurs have a valuable understanding of the AI-enabled future. Engage with them to improve your organisation's understanding of AI, and how its potential could unlock strategic value for your organisation in the long term.
- Early stage companies can be powerful enablers of innovation. Explore opportunities to collaborate with early stage companies by creating horizontal innovation departments and engaging in proof-of-concept projects.
- To maximise value from early stage companies, consider a simplified procurement process, adopt a collaborative mindset, provide continual feedback and expect capabilities to evolve over time.
- Your company's data and referencability are valuable assets for early stage companies. Explore, reasonably, opportunities to shape a supplier's offering to your organisation's specific needs, given your value to the supplier.
- AI entrepreneurs will face challenges, including access to talent and difficult productisation processes, that your organisation will encounter if it develops AI capabilities internally. Through test-and-learn engagements with AI startups, develop your own organisation's talent and productisation strategies.

## Entrepreneurs

- AI has the potential to create value in most business processes and can be a powerful tool for all early stage companies – not just 'AI companies'. Identify opportunities to apply AI to business problems and develop an AI strategy to avoid losing competitive advantage.
- To attract customers and investors, articulate solutions to business problems rather than AI technology as an end in itself.
- Given their importance and difficulty, from the inception of your company develop strategies for data access, AI talent recruitment and productising AI. Plan for the long term.
- Create buy-in across your company, and processes for cross-functional collaboration, to support the effective delivery of AI.
- View AI as a capability, not a feature. Anticipate ongoing development and resource the initiative accordingly.
- AI can improve your own company's processes as well as customers'. Look within your company for opportunities to automate manual processes and free personnel to focus on client activity.

## Investors

- Identify founders, who combine a profound vision of AI's ability to unlock value with the ability to articulate to buyers down-to-earth solutions that address business challenges.
- Prioritise evaluating AI companies' access to data and ability to attract AI talent, given the importance of these factors to AI companies' success.
- Evaluate the extent to which leadership teams have the necessary domain expertise and account management capabilities to engage with large buyers, given demanding go-to-market dynamics.

## Entrepreneurs anticipate a new AI-driven future

# "It's super clear to me we are moving towards a completely different reality in the coming decades."

## Timo Boldt, Gousto

Entrepreneurs believe AI will have a "profound effect." (Richard Potter, Peak). "The impact of AI will be like that of electrification." (David Benigson, Signal Media). By enabling companies to incorporate broader data sets into analyses, and identify patterns in data more effectively, AI will improve decision-making and increase automation. "An AI system is incredibly good at digesting data, drawing out patterns and identifying correlations at near-instant speeds." (Emily Foges, Luminance). As a result, "AI drastically alters the information available for decisions – and helps companies make better and smarter decisions with greater business impact. With AI we can deliver insights with real business value far faster, far more effectively and far more accurately." (David Benigson, Signal Media).

Entrepreneurs highlight that AI will impact every sector, from energy and healthcare to law and manufacturing. "The applications of AI are endless." (Timo Boldt, Gousto).

**Energy:** "The ability to harness, move and utilise energy is directly linked to our prosperity and well-being. AI is able to process data captured from the physical world in real-time to help us make better decisions about the flow and use of energy at a global scale." (Fabio Kuhn, Vortexa).

**Tim Sadler**
CheckRecipient

**Healthcare:** "The impact on healthcare will be huge. With patients living longer and greater incidence of chronic disease as a result, we either have to recruit thousands more doctors and nurses or ask how we can use technology to better leverage the people we have. AI multiplies the efforts of a single physician." (Chris McCann, Snap40).

**Nicole Eagan**
Darktrace

**Law:** "AI is starting to have a transformative impact on the legal sector. With AI taking the burden of low-level cognitive tasks, lawyers can optimise their practice and work smarter, faster and more effectively." (Emily Foges, Luminance).

**Manufacturing:** "AI's impact on manufacturing will be massive. The sector is data-rich, but not doing a lot with that data. Using AI, we enable manufacturers to get value from the data they have." (Simon Kampa, Senseye).

Most business functions, from analytics and compliance to cybersecurity and marketing, will also be improved through AI. "AI will be at the centre of business." (Dmitry Aksenov, DigitalGenius).

**Analytics:** "In the IT industry, AI can fix a broken model. Companies shouldn't pay for consulting work on a time and materials basis, or try to make best use of software themselves. They should pay for guaranteed results. AI can democratise data analytics, offering advanced technology to all." (Richard Potter, Peak).

**Compliance:** "AI is having a disruptive impact. AI can automate compliance, providing a better user experience and reducing costs, while delivering results that are superior to what humans could achieve." (Tim Sadler, CheckRecipient).

**Customer Service:** "Imagine customer service inquiries that are solved in minutes, not hours or days, regardless of the channel being used. AI will make that possible, by automating repetitive parts of agents' workflow and enabling faster customer service resolutions." (Dmitry Aksenov, DigitalGenius).

**Cyber Security:** "Cyber security is one of the greatest challenges of our day. In this age of limitless data and complex networks, humans can't keep up, perfectly, 24/7. AI is having a huge impact." (Nicole Eagan, Darktrace).

**Marketing:** "I think AI is fundamental and will have a profound impact in marketing. The art of storytelling hasn't gone away. But to do that at scale now is incredibly difficult." (Alex Vaidya, StoryStream).

Innovative early stage companies recognise the competitive advantage they provide to buyers. "We can offer real-time, hyper-relevant monitoring and analysis in 40 languages – while competitors offer next-day services." (David Benigson, Signal Media). "There's much excitement about AI in sectors that tend to be margin sensitive and driving for competitive advantage." (Simon Kampa, Senseye).

AI technology is expected to become ubiquitous. "We believe AI will become a fundamental part of every organisation in the next five years." (Alex Vaidya, StoryStream). "In five years, everyone will presume you're using AI." (Tim Sadler, CheckRecipient). "Today, we're talking about humans being supported by AI. In five years, we'll see AI running most repetitive parts of an organisation, managed by people focusing on the high-touch inquiries." (Dmitry Aksenov, DigitalGenius).

**Dmitry Aksenov**
DigitalGenius

## Early stage companies offer buyers innovation and flexibility

Early stage companies can be key enablers of innovation for large buyers. "There is huge opportunity for established organisations to harness the forward-thinking culture and technology of startups to bring innovation to their own businesses." (Emily Foges, Luminance). While AI solutions today are nascent, "they can solve a wide range of problems." (Alex Vaidya, StoryStream).

**"There's real opportunity for would-be clients to get in early and help shape an AI service around their bespoke needs."**

**David Benigson, Signal Media**

**Timo Boldt**
Gousto

For buyers willing to engage with early stage companies, the advantages are significant. Early stage companies "have a direction and compass, but not a detailed roadmap." (David Benigson, Signal Media). "Early adopters in the UK and US recognise they can shape the product and proposition. They know that if they give feedback, we'll seriously consider implementing it." (Chris McCann, Snap40). "Early stage companies will often dedicate more time and resources to a client than later stage companies can." (Nicole Eagan, Darktrace).

## Buyers maximise value through collaboration and simplified procurement

Being open to innovation is essential for buyers to maximise value from early stage companies. "A lot of it is cultural. Companies need to be open about engaging with startups." (Simon Kampa, Senseye). Buyers can catalyse innovation, and engagement with early stage companies, by: creating horizontal innovation departments that seek sources of disruption; structuring proof-of-concept programs to test products in less demanding environments; and initiating corporate venture capital initiatives. During deployments, "constructive feedback, and seeking solutions together rather than standing off, is by far the best way to engage." (David Benigson, Signal Media).

**"Working with a very collaborative approach is key."**

**Alex Vaidya, StoryStream**

Procurement processes are at best a headwind, and at worst a barrier, to early stage companies' engagement with large buyers. Enterprise procurement processes are rarely suited to suppliers with small balance sheets and limited track records. Simplified procurement processes for early stage suppliers can assist.

Conversely, there are steps early stage companies can take to ease buyers' engagement. Entrepreneurs recommend that early stage companies: ensure they receive sufficient information to understand customers' requirements deeply; offer pilot projects to demonstrate value before requiring commitments; focus on end user experience to increase client-side adoption; and manage expectations that development will be an iterative process.

**Emily Foges**
Luminance

## Successful entrepreneurs offer solutions, not technology

Effective entrepreneurs solve tangible business problems instead of focusing on technology as an end in itself. "Always focus on the problem you're using AI to solve, rather than the AI technology. Customers don't care how you're solving the problem." (Tim Sadler, CheckRecipient). Others agree. "You need to have a strong use case and need for AI. Otherwise it's very likely it won't have any impact." (Timo Boldt, Gousto). "AI itself doesn't solve anything. Use it to solve things." (Simon Kampa, Senseye).

AI entrepreneurs are identifying repetitive, data-intensive problems to which AI is well suited – both for customers and within their own companies. "Machine learning can transform predictive analytics for lead scoring, churn propensity, price optimisation, demand forecasting and more. Internally, we use AI to automate our day-to-day work, which enables our team to help more companies and deliver greater value to clients." (Richard Potter, Peak). "Work out what parts of your business require intensive repetitive effort – that's where AI can be most effective internally." (David Benigson, Signal Media).

**Richard Potter**
Peak

Successful entrepreneurs are also mindful of contextual considerations. In some sectors and business functions, transparency around AI-led decision-making is important. "In healthcare it's not good enough to say you can't look inside the algorithm. There's a greater need to understand how, and why, a model is doing what it's doing." (Chris McCann, Snap40). In other sectors, enabling behaviour change is key. "No matter how sophisticated the technology, most users won't have the time or inclination to learn and adapt to a complicated new system. Entrepreneurs should think as much about usability and approachability as underlying mathematics." (Emily Foges, Luminance).

**"Users won't have the time or inclination to adapt to a complicated new technology. Entrepreneurs should think as much about usability as underlying mathematics."**

**Emily Foges, Luminance**

**Simon Kampa**
Senseye

## Data, talent and productisation are key challenges for AI startups

Entrepreneurs highlight the limited availability of training data, competition for AI talent, and the difficulty of creating production-ready technology as key challenges when developing AI.

**"After people, data is the single most valuable element of an AI company. The right data can massively accelerate the feedback loop for AI models, making it virtually impossible for others to catch up."**

**Fabio Kuhn, Vortexa**

### 1. Access to training data is critical

Data is "the lifeblood of any AI. Without it, nothing happens." (David Benigson, Signal Media). "After people, data is the single most valuable element of an AI company." (Fabio Kuhn, Vortexa). Access to initial data sets for training is challenging. "It's a classic chicken and egg problem. Early customers, and thus data, are hard to get when you don't have any existing reference client." (Tim Sadler, CheckRecipient).

**David Benigson**
Signal Media

Companies mitigate the difficulty by developing powerful use cases – "customers won't give up their data unless you're offering them real value." (David Benigson, Signal Media) – and by implementing a data acquisition strategy from early in their lives. "We started collecting data very early in our journey." (Timo Boldt, Gousto). Compromising on early pricing to secure access to valuable customer data can be effective.

**Chris McCann**
Snap40

### 2. Recruiting AI talent is challenging

"The number one challenge when developing AI is recruiting the best (human) brains. It takes effort, but is non-linear. In complex problems, a genius can do what an army of people can't, and often, you only need a handful of geniuses to 'make a dent in the universe'." (Fabio Kuhn, Vortexa). "Access to talent, and its competitiveness, is the biggest challenge." (David Benigson, Signal Media).

Startups compete with multiple categories of competitors – including large technology companies (Google, Amazon, IBM, Microsoft, Facebook), banks, professional service firms, and other early stage companies – for data scientists, AI experts and AI engineers. Recruiting staff that have a balance between theoretical expertise and commercial experience, and experience running an AI team, are additional difficulties. "Because it's a nascent field, most of the people we interview are highly academic. But they haven't productised at scale. We've had to be super selective." (Chris McCann, Snap40).

London is "a good place to be, when looking for AI talent." (Dmitry Aksenov, DigitalGenius). "London has one of the best pools of AI talent in the world – which is the main reason why we are here." (Fabio Kuhn, Vortexa). To identify and attract talent, entrepreneurs recommend "building deep relationships with academic institutions, being an active member of research communities, publishing papers and collaborating with universities. We try to engage with developers well before they're looking for a job, and let them do what they love." (David Benigson, Signal Media).

### 3. Developing production-ready AI is difficult

"Taking what works well in a lab and getting it to work in a diverse population is a big challenge." (Chris McCann, Snap40). "Developing AI in a lab on static datasets is fun, but running AI in production is very hard. The real world is full of black swans and exceptions. We've learned to overcome them by getting great at cross functional collaboration, building integration with the tech team, and constant monitoring of risk." (Timo Boldt, Gousto). Entrepreneurs recommend "taking AI into the real world as soon as possible. For AI to work on real data in real environments, it can't just be trained in the lab on small, controllable sets." (Nicole Eagan, Darktrace).

**Alex Vaidya**
StoryStream

Beyond productisation, true innovation is demanding. "Most data scientists take existing algorithms, mash them together, and see what they can do with data. We've had to do fundamental research to create new algorithms." (Simon Kampa, Senseye). "Finding the balance between innovation and impact is also key. Without being in-market, it's very hard to know whether the extra 1% is really adding value to the client experience." (David Benigson, Signal Media). Feedback loops between development and customer success teams are valuable.

### 4. Commercial messaging must resonate

High levels of interest in AI present difficulties as well as opportunities. "There's a lot of marketing language out there about AI. Noise in the market isn't always helpful – since many others aren't actually doing heavy-duty machine learning." (Simon Kampa, Senseye). Messaging may need to overcome buyer reticence. "Integrating advanced technology into a sector, such as law, known for conservatism will always pose a challenge." (Emily Foges, Luminance). "We go through a change management program to educate the workforce on our 'human plus AI' approach. We explain that AI takes care of repetitive tasks so people can focus more on bigger things." (Dmitry Aksenov, DigitalGenius).

**Fabio Kuhn**
Vortexa

## Customer focus, continual evolution and long-term planning are key success factors for AI entrepreneurship

For early stage companies developing AI, leading entrepreneurs offer five recommendations:

### 1. Identify the customer benefits of AI

"It's very easy to use AI as a me-too, jump on the bandwagon idea. But you can't sell AI unless it has a very clear value to your end customer. If you're going to invest in AI, you need to be clear about what the benefit is and how you can differentiate using it." (Alex Vaidya, StoryStream). "Don't use AI just because you think it'll sound good." (Chris McCann, Snap40).

### 2. Anticipate continuous evolution.

"Remember that AI is a capability, not a product. It's always improving, and the more exposure it has to stimuli the faster it will learn. The more you push the envelope, the better it will be." (David Benigson, Signal Media).

### 3. Develop a data access strategy

"The more data your AI has, the better its output will be. So make sure you have enough of it. Build access to data at scale from day one." (David Benigson, Signal Media). Entrepreneurs recommend investing significantly in data ingestion, processing and management systems to provide a foundation of clean data.

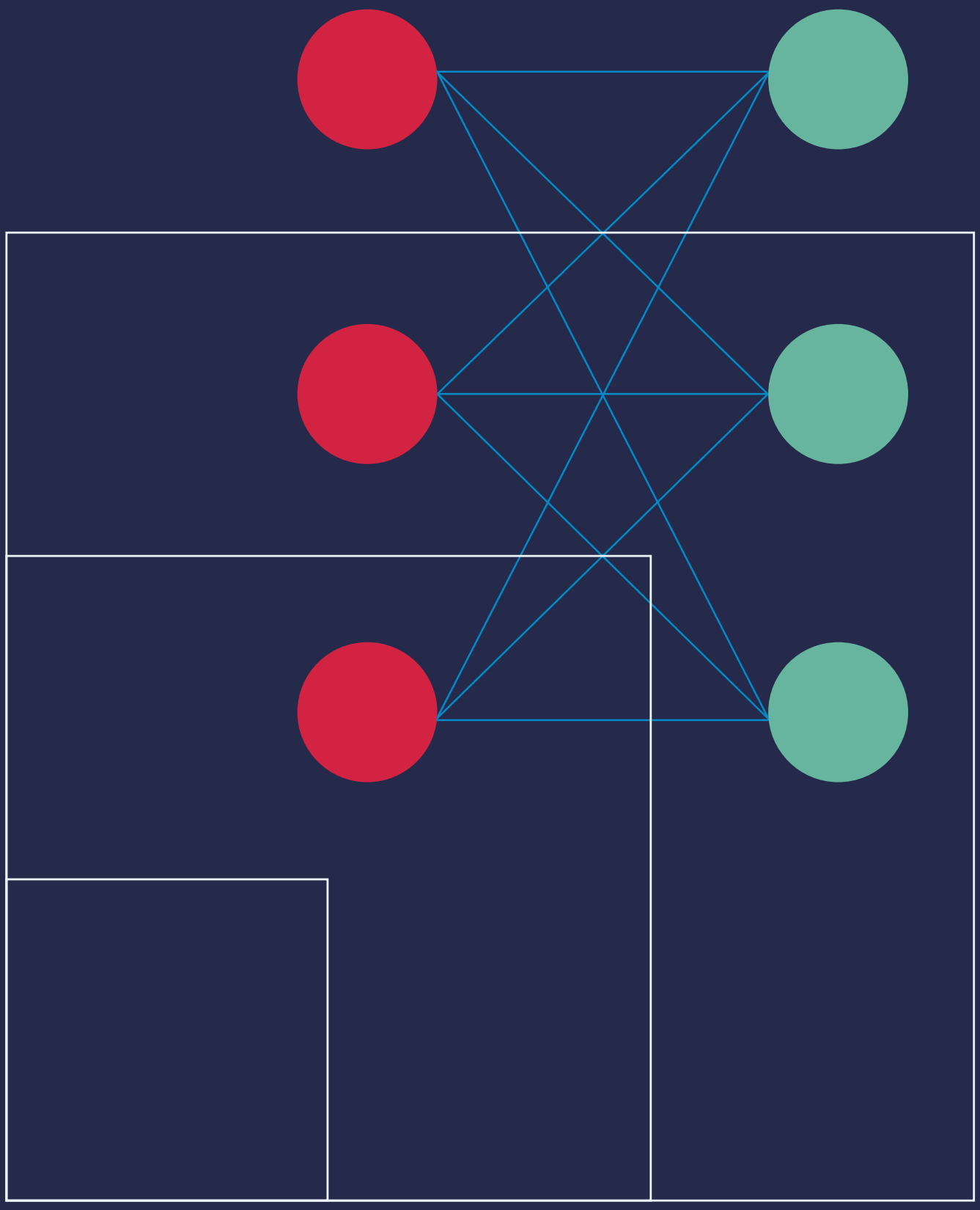
### 4. Adopt a holistic, long-term view

"AI capabilities can improve everything, from customer experience to business performance. Plan for the long-term and then obsess about capabilities to make your vision come true over five to ten years." (Timo Boldt, Gousto).

### 5. Persevere

"For AI companies, the ability to solve some of the really hard problems in the world takes time and depth. It follows a different curve. It requires tremendous persistence. Endurance is key." (Fabio Kuhn, Vortexa). "As with anything worth doing, AI is hard." (Richard Potter, Peak).

**"Plan for the long term and then obsess about capabilities to make your vision come true over five to ten years."**
**Timo Boldt, Gousto**



# Chapter 10

# An investment framework for AI


## Summary

- The AI paradigm shift presents opportunities to invest in disruptive early stage software companies as well as public companies developing competitive advantage.
- AI acquisitions have increased significantly, averaging ten per month in 2017.
- A first wave of acquisitions focused on core AI technologies – 'deep-tech' AI research or AI-powered computer vision and language capabilities with cross-sector utility.
- We are entering a second wave of AI investment and exits. Capital is being allocated to developers of vertical applications.
- We provide our AI Investment Framework, which identifies 16 success factors for early stage, applied AI companies. We divide the 16 factors into three categories: value potential, value realisation and defensibility. Applying the success factors helps highlight attractive investment opportunities.
- Keys to value potential are: scope for value release and disruption; unattractive alternatives; suitability of AI to a business problem; a path to acceptable technical performance; and suitability of available data.
- Keys to value realisation are: management commerciality; quantifiability of ROI; buyer readiness; benign regulation; and deployment scalability.
- Keys to defensibility are: distance from AI monoliths' offerings; domain complexity; data network effects; proprietary algorithms; attractive AI talent dynamics; and strong capitalisation.

# Recommendations

## Executives

- Apply the 16 factors to assess your own organisation's AI capabilities.
- Use the 16 factors to identify strengths and weaknesses, and support due diligence, of AI partners and potential acquisition opportunities.

## Entrepreneurs

- Evaluate your company's strengths and weaknesses against the 16 factors.
- Highlight to buyers and investors, as appropriate, your company's strengths in key criteria including value release, management commerciality, quantifiability of ROI, data network effects, AI talent, vertical focus and domain expertise.
- Address headwinds to value realisation by automating deployment requirements, particularly customer data processing, and focusing early on building a capable sales organisation.
- Investors decline to invest in startups due to doubts about management commerciality and tangibility of ROI more than for any other reasons. Focus remediation and messaging on these critical issues.

## Investors

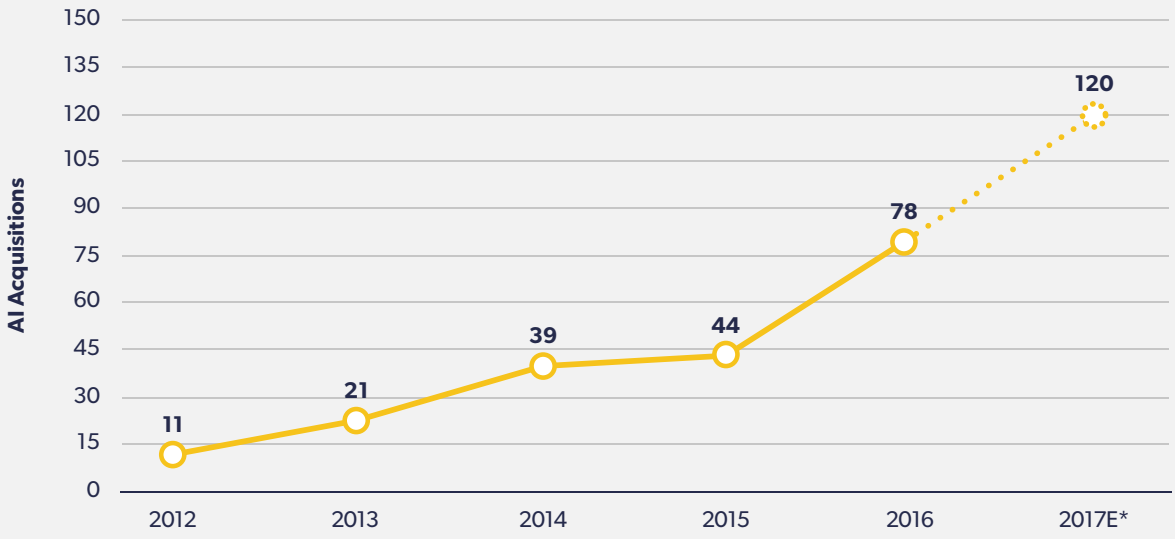
- While most companies will incorporate AI in the years ahead, today there remains a category of companies disrupting incumbents by placing AI at the heart of their value proposition. Consider developing a basket of AI-driven investments.
- Apply the 16 factors, in addition to your usual considerations, to evaluate early stage applied AI companies.
- Remain open-minded to select investment opportunities in horizontal AI providers. While rarer, and with differing dynamics to application providers, companies with world-class technology valuable to an AI platform provider can be an attractive technology or talent acquisition.
- Get in touch with us to discuss your perspective. Where do you agree, or disagree, with our thinking?

## AI acquisitions have increased significantly

The AI paradigm shift presents opportunities to invest in disruptive private software companies as well as public companies establishing competitive advantage.

Acquisitions of early stage AI companies have increased significantly, annually, since 2012. If activity in 1H17 is sustained, AI acquisitions in 2017 will average ten per month (fig.50).

**Fig. 50. AI acquisitions have increased annually since 2012**



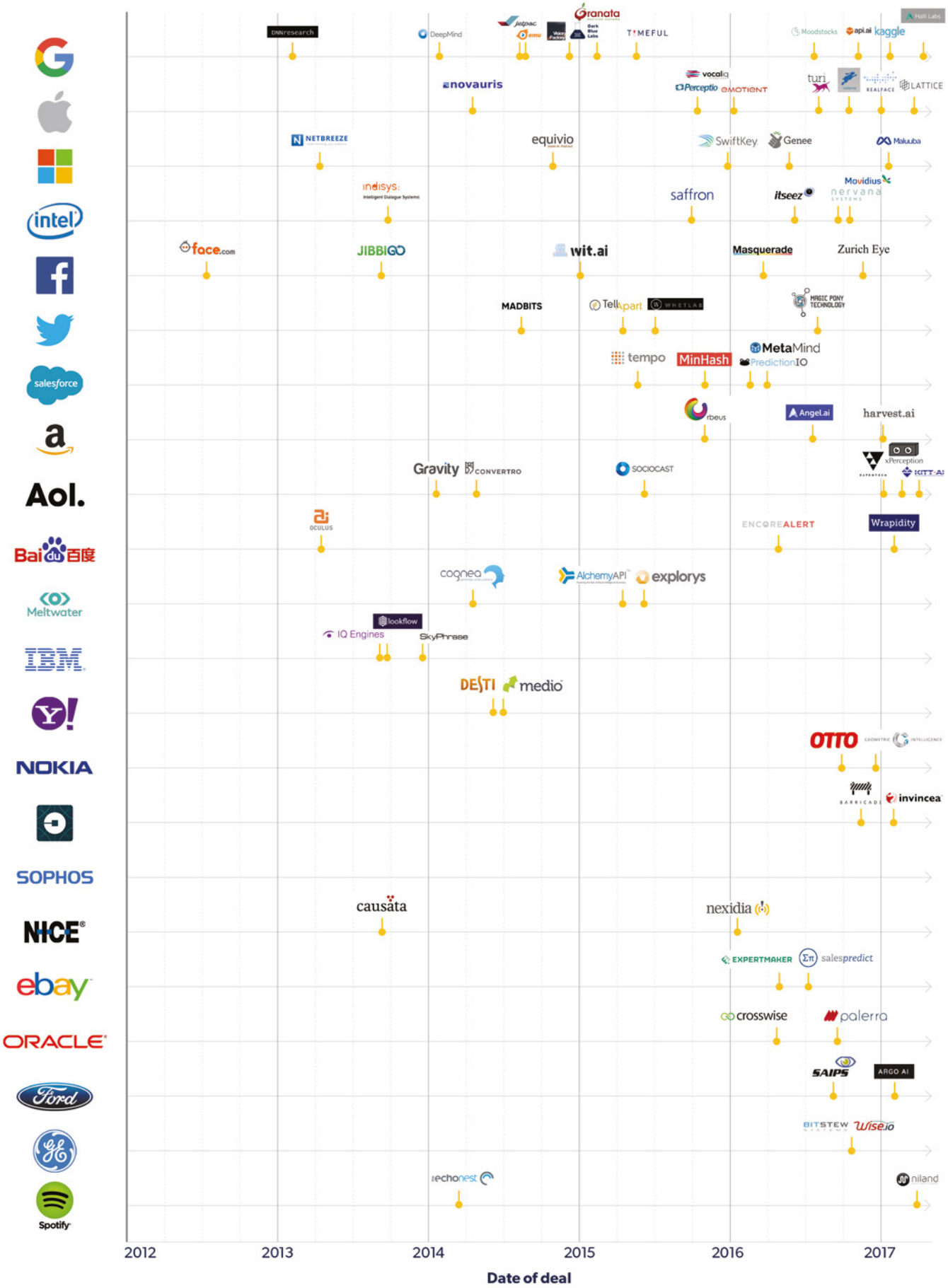

*Estimate, extrapolated from 60 acquisitions in 1H17

Source: CB Insights

## The first wave of acquisitions focused on core AI technologies

The first wave of capital allocation and acquisitions in AI focused on providers of 'deep-tech' AI research (for example, Deep Mind) and AI-powered computer vision and language capabilities with cross-sector utility (Perceptio, Magic Pony, Wit.ai, Equivio). Global consumer and enterprise technology companies, including Google, Apple and Microsoft, have led consolidation (fig.51, overleaf). Innovators recognised early that AI unlocks value from large data sets, particularly visual data, and offers new opportunities for growth – from novel ways for people to interact with computers (voice control of smartphones and in-home devices) to new product categories (autonomous vehicles).

**Fig. 51. Google has led an acceleration in AI acquisitions**




Source: CB Insights

## The second wave of activity will focus on application providers

We are entering a second phase of AI investment and acquisitions. Acquisitions of core AI technology companies will continue. However, as AI technologies mature and become more accessible, focus will increase on providers of AI-powered vertical applications. 90% of early stage AI companies in the UK are now applying AI to address challenges in specific business functions or sectors (MMC Ventures). We describe 31 business processes being addressed, across eight sectors, in Chapter 4.

## Our Investment Framework describes success factors for applied AI companies

We have developed an Investment Framework that identifies 16 success factors for early stage applied AI companies. The Framework is applicable to the nine in ten companies applying AI to solve a problem in a specific business function or sector. Success factors for developers of 'core' AI technologies differ.

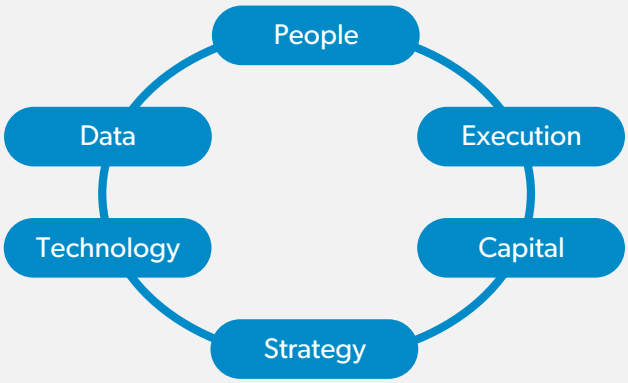
Companies that have the potential to create significant value, can realise their potential, and can defend their value, offer the prospect of attractive returns. Accordingly, we group the 16 success factors into three categories: value potential, value realisation and defensibility (fig. 52). The factors span six competencies: strategy, technology, data, people, execution and capital (fig. 53).

**Fig. 52.**

**16 success factors: in three categories**


**Fig. 53.**

**16 success factors: across six competencies**




Source: MMC Ventures

When evaluating AI companies, there are new factors to consider given the unique dynamics of AI, such as data network effects, and traditional considerations on which to place greater emphasis, such as management commerciality. The traditional considerations we emphasise follow our meetings with 250 early stage AI companies in the UK.

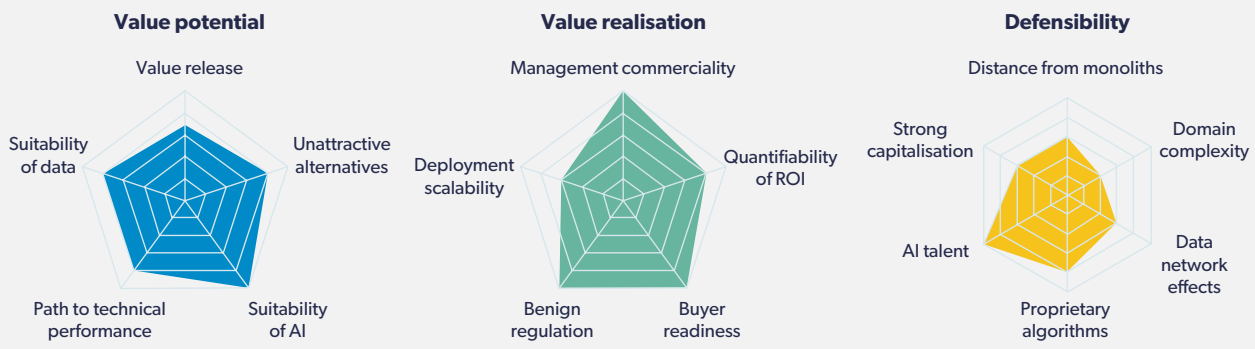
### 16 success factors for applied AI startups

| **Value potential** | **Value realisation** | **Defensibility** |
|---|---|---|
| Value release | Management commerciality | Distance from monoliths |
| Unattractive alternatives | Quantifiability of ROI | Domain complexity |
| Suitability of AI | Buyer readiness | Data network effects |
| A path to technical performance | Benign regulation | Proprietary algorithms |
| Suitability of data | Deployment scalability | AI talent |
| | | Strong capitalisation |

Source: MMC Ventures

Prospects can be assessed against this framework to help identify strengths and challenges (fig. 54).

**Fig. 54. 16 success factors for applied AI startups**




Source: MMC Ventures

## Value potential

AI companies with the potential to create significant outcomes can be identified by: their potential to unlock value and disrupt business systems; unattractive alternatives; the suitability of AI to problems they address; a viable path to technical maturity; and available data to train and deploy their AI systems.

### 1. Value release

Through predictive success or process automation, attractive applied AI companies unlock value in business systems.

Investors can assess a supplier's ability to create revenue for its customers by:

- increasing uplifts in conversion, yield, throughput, price, or other direct drivers of revenue;
- reducing churn through improved customer experience, stronger personalisation, enhanced customer service or deeper brand loyalty;
- enabling additional streams of revenue through the identification of new customers, up-sell and cross-sell opportunities, and markets.

Attractive suppliers can also decrease buyers' costs by:

- reducing surplus spend, excess resourcing or personnel requirements through improved predictive efficiency, process efficiency or process automation;
- reducing economic leakage through, for example, improved compliance.

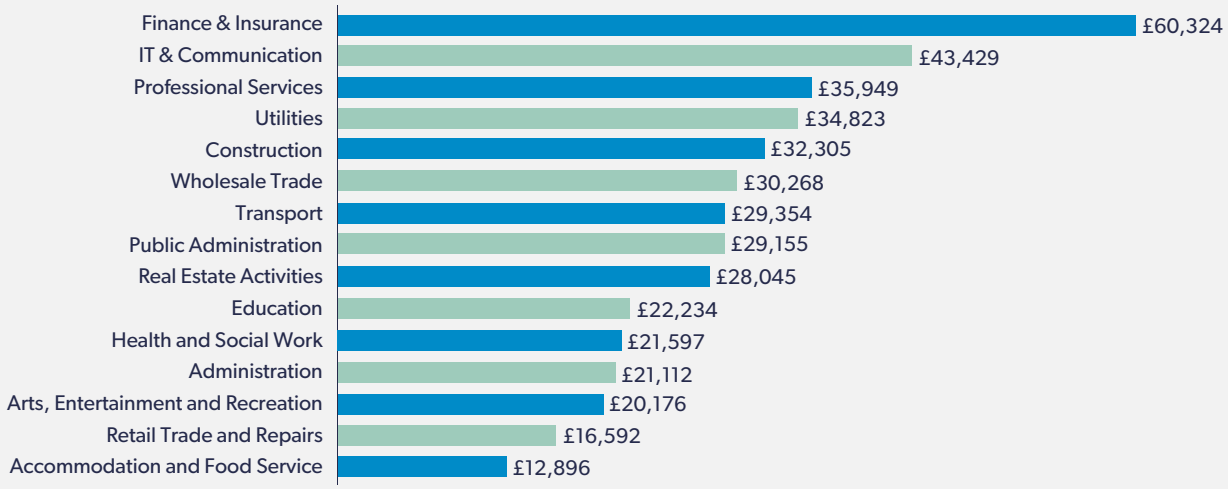
Companies that 'disrupt', enabling new categories of customer to use a service, have the potential to create particularly large outcomes. Companies that automate medical diagnosis, for example, can deliver primary care at low cost. By making healthcare affordable, a larger proportion of the global population can access care, growing the market of healthcare consumers. Few businesses disrupt and a business need not disrupt to be attractive. By enlarging markets, however, disruptive companies can create outsized outcomes.

### 2. Unattractive alternatives

Scope for value creation is greater when the cost or availability of alternatives to AI are prohibitive. Typically, the alternative to AI is investment in human or other resources. When alternatives are costly, scarce, inaccessible or non-scalable, scope for value creation is significant.

Human labour is typically the immediate and most expensive alternative to digitisation. In the UK, more AI startups focus on the finance sector than any other. Activity in general IT and Infrastructure is also extensive. finance, IT and utilities are three sectors where average salaries are the highest (fig. 55). There are additional opportunities for AI companies focused on professional services.

**Fig. 55. AI's value is greater when alternatives are expensive: (average annual employee compensation by sector)**




Source: Office Of National Statistics. Figures extrapolated from average weekly earnings, including bonuses.

### 3. Suitability of AI

Investors can assess the extent to which AI is suited to a business challenge. AI is well suited to problems that are arduous, complex or inscrutable.

**Arduous problems** are those in which people are competent and could codify a solution into a program, but it is impractical to do so.

**Complex problems** are those in which people are competent, but codifying capability into a program is difficult. Recognising objects in images is a complex problem.

**Inscrutable problems** are those in which people are not competent. People cannot label or organise data to underpin a predictive engine. Deep learning approaches to AI excel at inscrutable problems because neural networks can determine parameters to optimise.

AI is poorly suited to unbounded problems and questions of causal inference.

**Unbounded problems:** AI algorithms cannot draw on knowledge beyond the data provided to them. For AI to be effective, problems need to be adequately described by the available data.

**Questions of causal inference:** AI is rarely suitable when causal inference is of primary interest. AI describes how data relate to one another, not the causal mechanism of their relationship. AI is poorly suited to prediction problems when the future will be dissimilar to the past, or where prior patterns will not reflect a new reality.

### 4. A path to technical performance

AI need not be 100% effective to be valuable. AI solutions typically need to offer only near-human, or ideally better-than-human, levels of performance to enable automation and process scaling. Investors should look beyond the immediate-term and assess whether a company has a path to a level of technical performance that unlocks value.

### 5. Suitability of data

For AI to create value, it needs suitable data sets on which to be trained and deployed. Investors should evaluate the extent to which a company can access suitable data. This can be gauged in the context of two stages of data manipulation required for AI:

**Data selection:** data availability; the existence of gaps and duplicate data; quality of data labelling; existence of bias in data.

**Data processing:** data fragmentation; data cleaning requirements; the need for data sampling; the need for data transformation, decomposition and aggregation.

Investors should also consider whether data sets will retain value. Data sets retain value if new iterations of algorithms can be tested, and improved, using historical data. This may not be possible. A chatbot provider's new algorithm may change the prompt shown to a user in a particular situation. A new prompt will trigger a different reply from a user. A large set of historic user replies therefore become decoupled, and potentially irrelevant, to the algorithm being trained.

## Value realisation

Successful companies realise their potential for value creation. Five factors are key for value realisation: management commerciality; quantifiability of ROI; buyer readiness; benign regulation; and deployment scalability.

### 1. Management commerciality

Many founders of AI companies have outstanding technical expertise. Commercial acumen, however, will significantly influence the success of their businesses. Most business-to-business software suppliers will require a direct sales team. Commercial founders will demonstrate a desire to build a large business, an urgency to go to market and the ability to build strong sales teams – either directly or by appointing experienced leaders.

### 2. Quantifiability of ROI

B2B companies that offer a quantifiable ROI enjoy greater adoption, benefit from shorter sales cycles and require less customer education. In select functions, such as sales and marketing, and sectors including finance, increased conversion or profits are apparent. In others, such as the human resources function, ROI must be articulated and linked with departmental performance indicators.

## Investors should assess whether buyers have the organisational buy-in to augment or disrupt existing workflows with AI.

### 3. Buyer readiness

Buyer readiness is conceived as a funnel with five stages: awareness, knowledge, liking, conviction and purchase. When evaluating buyers' readiness for an AI solution, investors may wish:

**to add to the funnel 'preparedness'.** Preparedness is an assessment of whether buyers possess suitable, accessible data sets for training and deploying AI systems, and whether buyers have the organisational buy-in to augment or disrupt existing workflows with AI.

**to consider issues of trust and control.** Trust is the ability to have confidence in the performance of an AI solution with limited human intervention. Levels of trust required vary by sector. Travelling in an autonomous vehicle, or using an automated medical diagnostic tool, require high levels of trust. Control describes the degree of desire for human involvement in systems even when trust is high. Where high levels of human control must be maintained, value release and scalability can be inhibited.

### 4. Benign regulation

Deep learning approaches to AI, involving artificial neural networks, are frequently 'black box' in nature. "It's not always clear what happens inside – you let the network organise itself, but…it doesn't necessarily tell you how it did it." (Nils Lenke, Nuance).

Investors must consider whether an AI supplier may face regulatory challenges regarding explainability. Is there a requirement to understand or explain the basis for a prediction or decision? If so, can the supplier adequately respond?

It has been reported that the European Union's General Data Protection Regulation (GDPR), due to become EU law in 2018, creates a 'right to an explanation', whereby customers can demand explanations of algorithmic decisions. The legislation is unclear. GDPR may only require companies to describe general processes for algorithmic decision-making and the data sets involved. Nonetheless, the direction of policy-making is clear, and towards greater consideration of transparency and bias in AI systems.

In some business-to-business functions (sales, marketing and business intelligence) explainability may be of secondary importance. In others including human resources, compliance, and fraud detection, explainability may be essential given legal or pragmatic considerations. Similarly, companies operating in certain sectors, such as financial services, may have greater compliance requirements than others.

### 5. Deployment scalability

The pace at which AI companies scale can be inhibited by challenging deployment dynamics. Data integration requirements can be extensive. Amalgamating, integrating and cleansing disparate customer data sets can limit time to value. Resources required from AI vendors can also be substantial, limiting capacity for new customer acquisition and margins. Many early stage AI companies have one third of their modestly-sized teams involved in deployment (MMC Ventures).

**"Given the personnel required for each deployment, we couldn't deal with more sales even if we had them."**

**CEO, early stage AI company**

AI companies that minimise deployment requirements, or automate data processing and deployment, can scale more rapidly.

## Defensibility

How effectively can an AI company defend the value it creates against competitors? Investors should consider six keys to defensibility: distance from AI monoliths; domain complexity; scope for data network effects; proprietary algorithms; AI talent; and strong capitalisation.

### 1. Distance from AI monoliths

Google, Amazon, IBM and Microsoft (GAIM) offer cloud-based AI services in areas including computer vision and language. The capability and scope of these services will continue to increase. In 2017 Google extended its computer vision capabilities into video, offering entity recognition, search and cataloguing of video. Google's ownership of DeepMind, effectively Google's AI research department, will enable novel technologies to filter down into broadly accessible services.

The performance and low cost of GAIM's AI services will commoditise all but the most sophisticated 'best-of-breed' competitors in equivalent areas.

Accordingly, AI companies with offerings distant from GAIM competencies will enjoy greater defensibility. Companies gain distance from GAIM primarily by developing solutions for specific business functions and industry verticals, and technologies in areas beyond generalised computer vision and language.

At present, GAIM's vertical ambitions are limited primarily to healthcare (Google, Microsoft and IBM) and transportation (Google), although in future some will experiment with vertical offerings in sectors relevant to their data sets and business models.

Early stage AI companies have the opportunity to enhance, and then reinvent, myriad processes in sectors ranging from manufacturing to law and agriculture. In these areas, GAIM lack the desire, data and domain expertise to compete at full strength.

### 2. Domain complexity

While focusing on an industry vertical or business function minimises competition from AI platforms, the dynamics of an AI company's chosen domain further broaden or narrow the 'moat' around the business.

Complex domains include those that require extensive industry expertise, have elaborate regulation, or present particularly complex technical or go-to-market challenges. Tackling a complex domain places a greater burden on a business; the bridge across the moat is narrower. Companies that survive, however, will enjoy greater defensibility. Companies that tackle complex domains, and have the capabilities to succeed, enjoy strong defensibility.

### 3. Data network effects

Attractive AI businesses create network effects through data, to develop lasting competitive advantage.

Companies with access to private, domain-specific data sets have unique training materials to improve their AI algorithms. A network effect develops. The more data secured, the better the company's product. With a better product, the company wins more customers at the expense of competitors. New customers bring additional data, fuelling a virtuous circle.

**Companies with access to private, domain-specific data sets have unique training materials to improve their AI algorithms. The more data secured, the better the company's product.**

An AI company offering fraud detection for the financial services industry will gain access to additional, non-public data with every customer acquired. A company leveraging only public data, such as web data, cannot develop the same defensibility. It may achieve competitive advantage by moving first, or scaling faster, but ultimately its algorithms will be replicable.

An AI company need only access and utilise – not own – a customer's private data to train its algorithms. Temporary access to incumbents' data is sufficient to neutralise much of the incumbent's own data advantage.

Scope for network effects, through access to private data, has second-order consequences. Early stage AI companies may sensibly prioritise access to date over short-term revenue. They may offer software without charge, or accept reduced revenue from initial customers, given the value of early customers' data.

### 4. Proprietary algorithms

While ever-better algorithms are available from open source libraries including TensorFlow, valuable AI companies create intellectual property by developing enhanced, proprietary algorithms.

A proprietary algorithm (in practice, frequently an ensemble of multiple algorithms) may offer: greater accuracy; broader functionality; faster performance; lower fragility; greater explainability; or results from a smaller training data set. Innovation comes by degree, from 'know-how' to novelty. 'Know-how' is the skilful implementation of existing algorithms for improved results. Novelty involves devising new approaches to problems and deploying them successfully.

The value of proprietary algorithms is underappreciated ("in AI, all the value is in the data"). In several areas of AI, including natural language processing, lack of data is no longer the primary inhibitor. In other areas, innovative algorithms are enabling high quality results from smaller data sets, and greater explainability.

### 5. AI talent

High quality AI talent is scarce and expensive. Open positions for even general data scientists grew 32% year-on-year in 1H16 (Procorre), outstripping growth in supply. Among UK developers, AI specialists also command the highest salaries (fig. 56).

Compelling companies demonstrate their ability to attract and retain high quality AI personnel at acceptable cost.

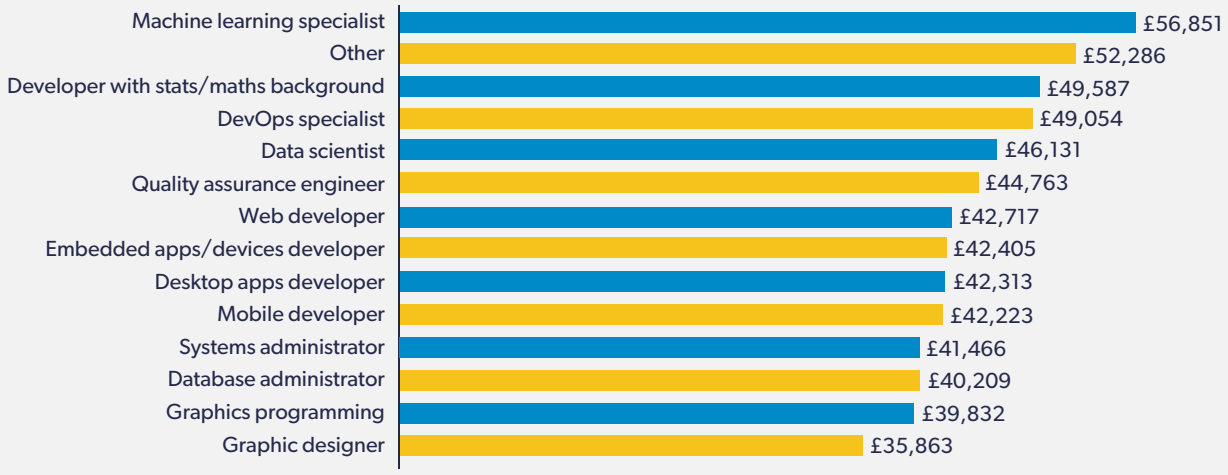
Early stage companies primarily compete with Google, Amazon, IBM, Microsoft, and leading consumer companies including Facebook, for top AI talent. Startups cannot, and need not, compete with the scale, security and pay offered by large companies. Effective startups market to candidates a greater opportunity to impact product; increased autonomy; faster cycles of innovation; greater freedom to publish; intellectual and technical challenges; and greater potential long-term financial rewards.

### 6. Strong capitalisation

AI companies have greater capital requirements given: the longer period of time required to develop a minimally viable product; long sales cycles associated with business-to-business sales; the cost of AI talent relative to other developers; and the requirement for extensive deployment resources, including personnel.

Effective AI companies use capital as a weapon to strengthen competitive advantage. While tackling inefficiencies – for example, by automating deployment – leading founders adequately capitalise their companies to withstand the journey to monetisation, offer competitive salaries to AI talent, and maximise their pace of customer acquisition to secure private data sets and a data network effect.

**Fig. 56. AI talent is expensive (average annual salary by technical area)**




Source: Stack Overflow Developer Hiring Landscape Report

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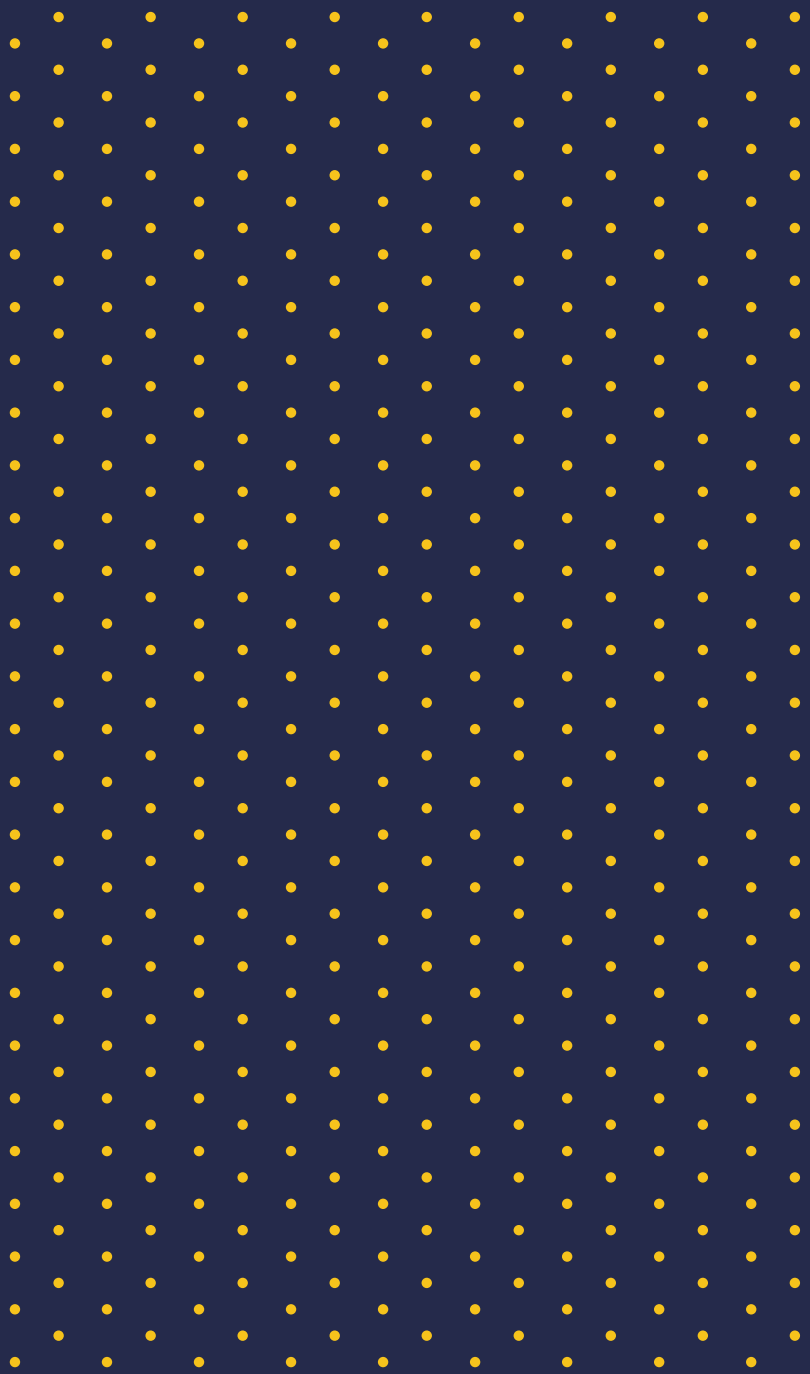

The State of AI 2017

# Inflection Point