McKinsey & Company

McKinsey Technology Trends Outlook 2022

Applied AI

August 2022

What is the trend about?

Applied AI uses intelligent application to solve classification, prediction, and control problems **to automate, add, or augment real-world business use cases.** As AI technologies rapidly push new frontiers of innovation, **business adoption** continues to **grow across use cases**

Selected AI technologies[1]
Foundational methods of AI

Machine learning (ML)

- Computer vision
- Natural-language processing (NLP)
- Deep reinforcement learning
- Knowledge graphs

Selected use cases[2]
Applications of AI at work

Risk management

Service operations optimization

Product and/or service development

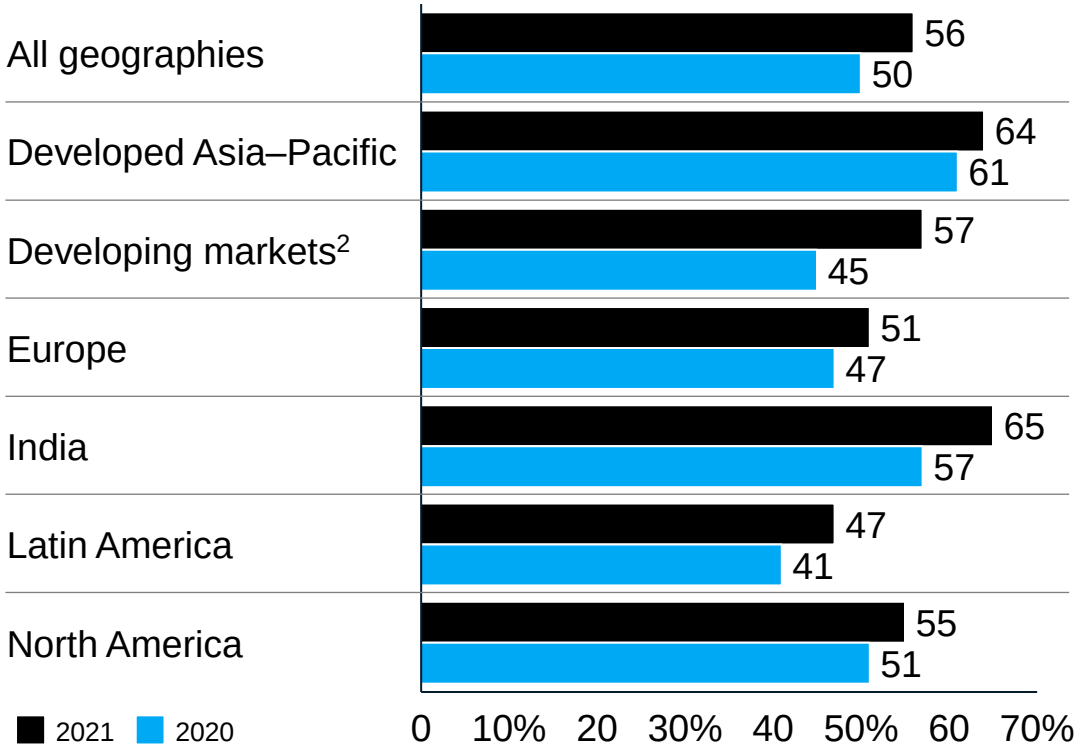
[1]Technologies are nonexhaustive and examples that are at the frontier of innovation and used across industries.
[2]Use cases are nonexhaustive and industry agnostic examples that are leading in business adoption.

Source: McKinsey analysis

Why should leaders pay attention?

AI adoption has continually increased, enabled by its financial investment and development for easier access[1]

AI adoption by organizations, 2020–21, %



[1]For details about easing ML development and integration, see "Industrializing machine learning," *McKinsey Technology Trends Outlook 2022*, McKinsey, August 2022.
[2]Including China, Middle East, and North Africa.

Source: Daniel Zhang et al., *The AI Index 2022 annual report*, Stanford University, Mar 2022; "The state of AI in 2021," McKinsey, Dec 8, 2021

Global expansion of AI

56%

Share of respondents to a 2021 global survey who said their organizations were adopting AI (up 50% from 2020)

Easier and more affordable AI implementation

94.4%

Improvement in training speed for AI models since 2018

Rapidly growing innovation

30×

Relative number of patents filed in 2021 vs. 2015 (compound annual growth rate of 76.9%)

Investment growth and intensified efforts

$93.5 billion

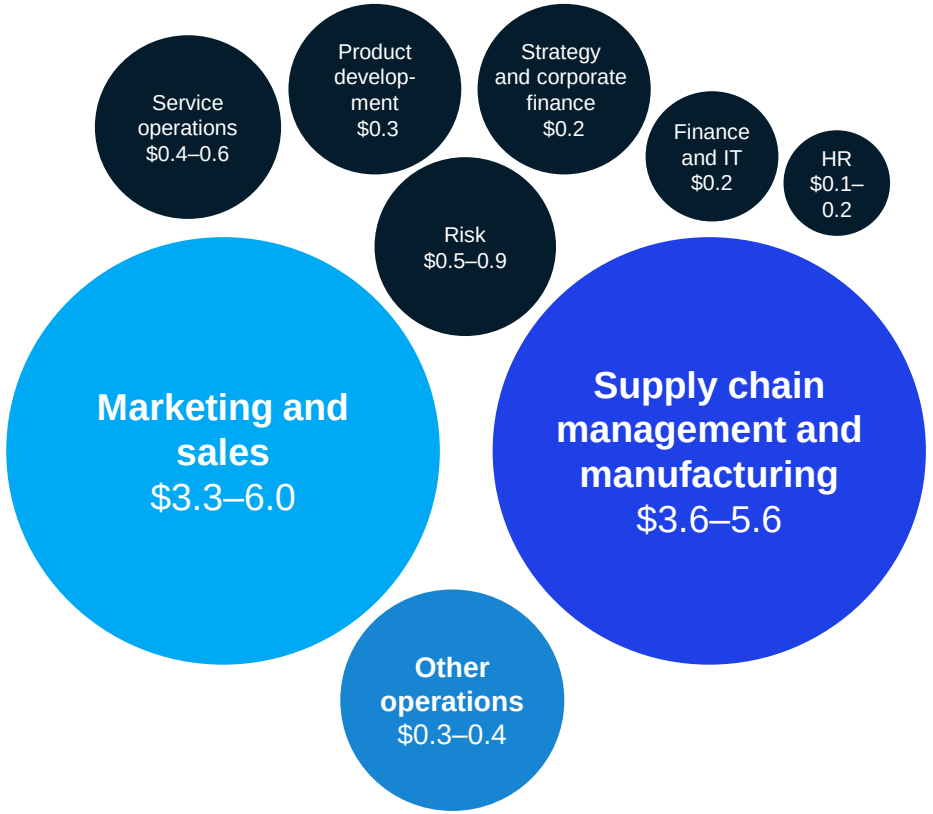
Private investment in AI-related companies in 2021, accompanied by higher concentration of efforts (doubling vs. 2020)

Why should leaders pay attention? (continued)

The potential value at stake from AI is $10 to $15 trillion ...

Global annual potential, forecast

Value at stake, $ trillion



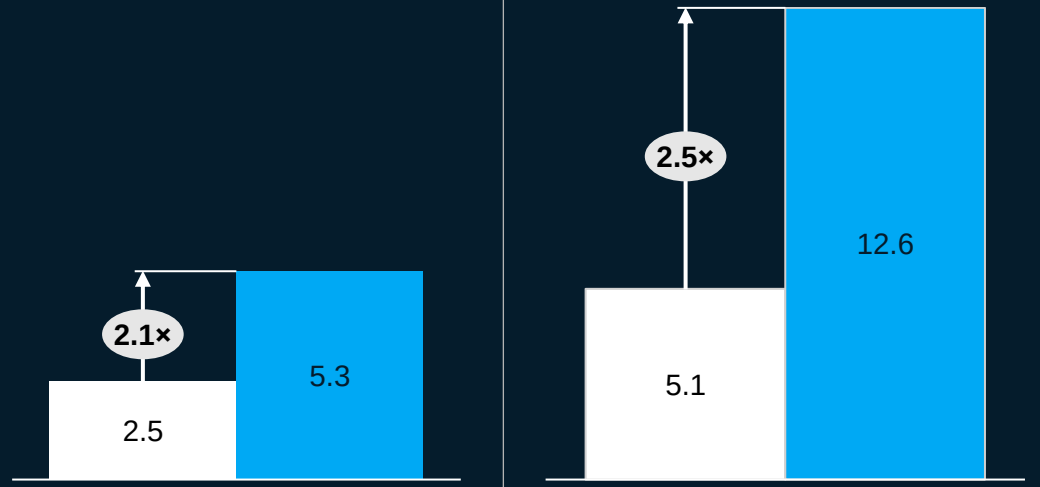
Source: S&P Global, Oct 2020; McKinsey Analytics Quotient data set

… and leaders adopting AI exhibit stronger financial performance

AI maturity and financial performance

Others Analytics leaders[1]

CAGR, %

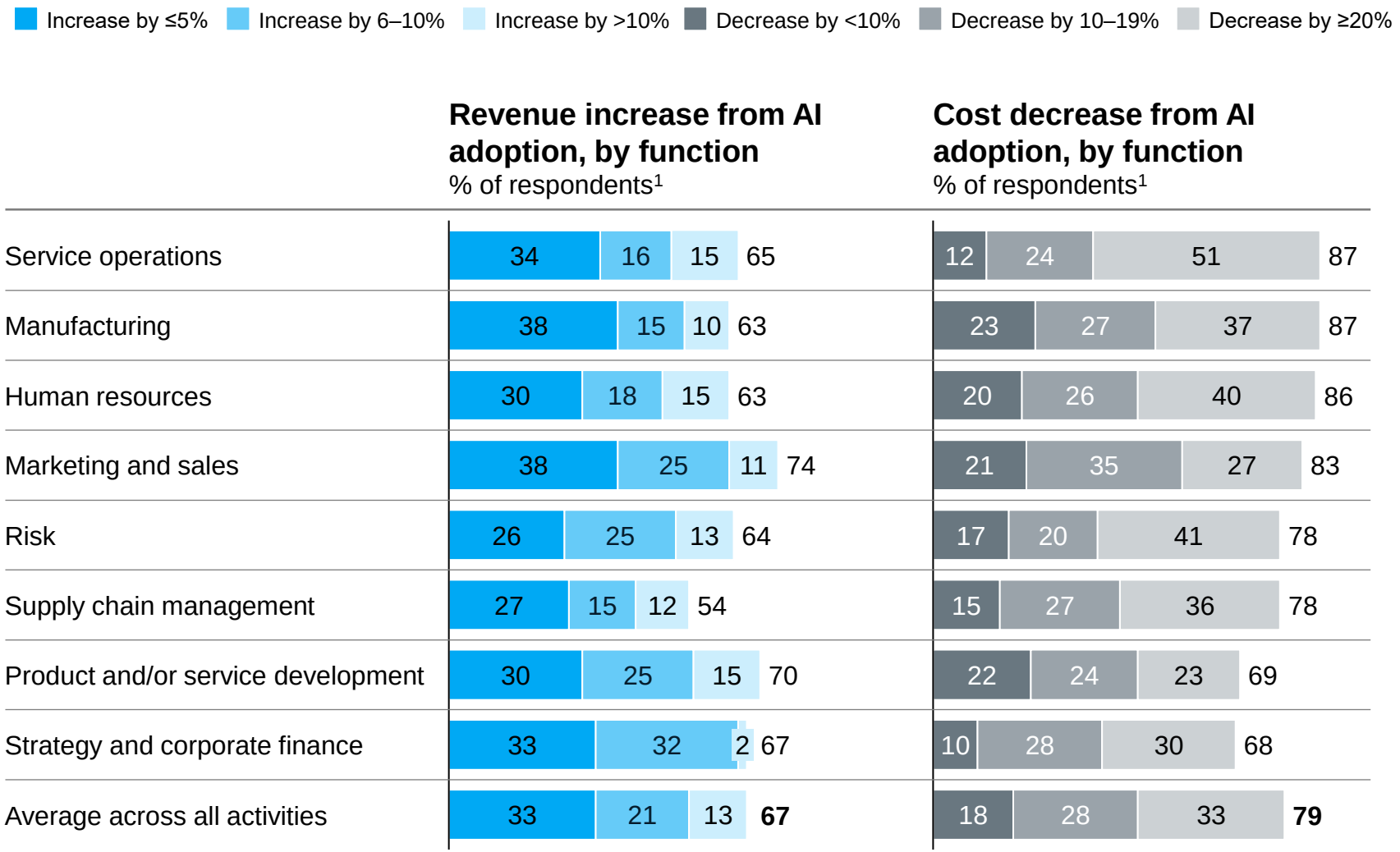


5-year **revenue**[2]

5-year **total return to shareholders (TRS)**[3]

[1]AI leaders are defined as the top quintile of companies that have that taken the McKinsey Analytics Quotient (AQ) assessment.
[2]Includes revenue through fiscal year 2019; during this time, the 5-year revenue CAGR of the S&P 500 index was 4.1%.
[3]Includes TSR through FY 2019; during this time, the 5-year TSR CAGR of the S&P 500 index was 11.7%.

Why should leaders pay attention? (continued)



[1]Earnings before interest and taxes.

Source: "The state of AI in 2021," McKinsey, Dec 8, 2021 (for FY 2020)

Across business functions, AI has already made notable financial impact

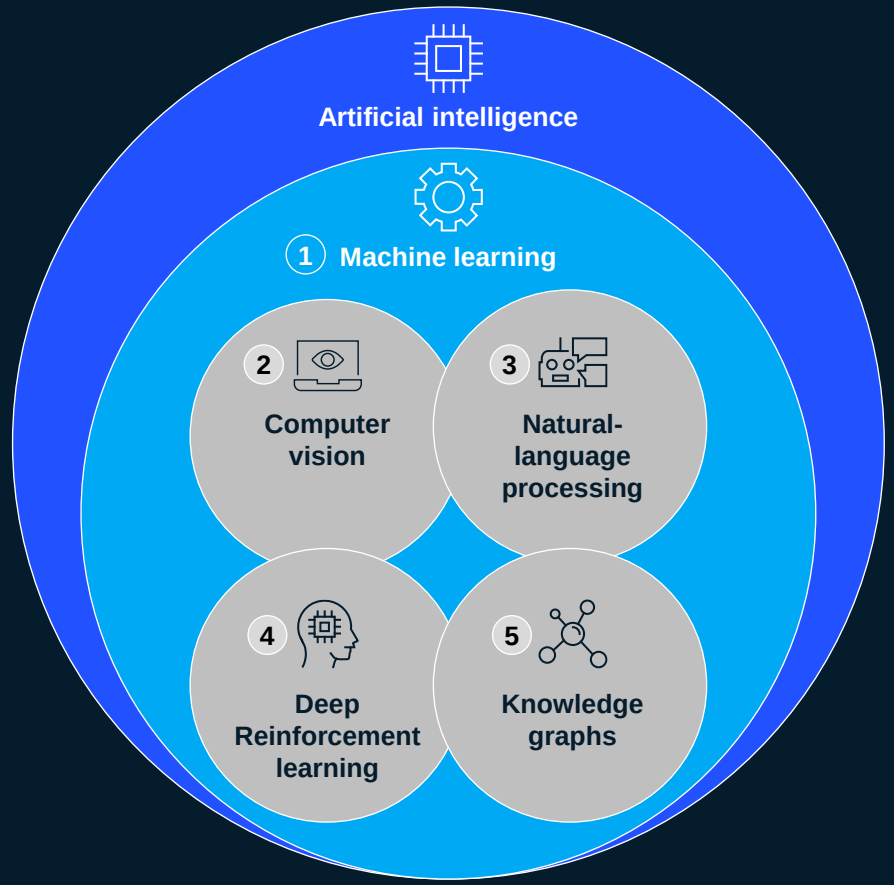
27%
Share of respondents who report at least 5% of EBIT[1] being attributable to AI

67%
Average share of respondents reporting a revenue increase via AI adoption

79%
Average share of respondents reporting a cost decrease via AI adoption

What are the most noteworthy technologies?

AI involves machines exhibiting intelligence,[1] encompassing various interconnected fields of technology[2]



Description	Example use case
1 **ML:** Subfield of AI that uses statistical methods to learn from data	Schedule optimization
2 **Computer vision:** Subfield of ML using visual data, such as images, videos, and 3-D signals, extracting complex information and gaining rich interpretations	Facial recognition as biometrics
3 **NLP:** Subfield of ML that involves processing, generating, and understanding language-based data, such as written text and spoken word	Speech recognition in a virtual voice assistant
4 **Deep reinforcement learning:** Combination of deep learning and reinforcement learning, in which an agent makes decisions within an uncertain environment using complex algorithms inspired by brain neural networks	Planning robotic-arm motion for the manufacturing line
5 **Knowledge graphs:** Collection of data points structured into a network to show complex relationships among themselves	Social-network analysis

[1]AI is nonprogrammatic intelligence exhibited by machines, in which they perform cognitive functions often associated with human minds. Cognitive functions include all aspects of perceiving, reasoning, learning, and problem solving.
[2]Technologies are not exhaustive and are examples that are at the frontiers of innovation and cut across industries.

Source: Expert input; McKinsey analysis

What industries and functions are leading in the adoption of AI applications?

AI adoption by industry and function, 2021
% of respondents

Industry	Human resources	Manu-facturing	Marketing and sales	Product or service development	Risk	Service operations	Strategy and corporate finance	Supply chain management
All industries	9	12	20	23	13	25	9	13
Business, legal, and professional	11	26	20	15	4	18	6	17
Consumer goods/retail	14	8	28	15	13	26	8	13
Financial services	2	18	22	17	1	15	4	18
Healthcare systems	10	4	24	20	32	40	13	8
Pharma and medical products	9	11	14	29	13	17	12	9
High tech/ telecom	12	11	28	45	16	34	10	16

Source: *AI index report*, McKinsey in collaboration with Stanford University Human-Centered Artificial Intelligence (HAI), Mar 2022

Technology-centric industries are leading adoption by businesses

Product and service development, service operations, and marketing and sales are the business functions leading adoption of AI

What industries are most affected by the trend?

A **diverse set of stakeholders** across all industries are experiencing the impact from applied AI, which can include **disruption in value chains, better financial outcomes**, and **improved operations**

Industry affected[1]	Example impact from the trend
 **Information technology and electronics**	Pervasive use across the tech industry and constituent sectors, such as software, hardware, and electronic devices (eg, use of generative AI models to create 3-D visuals for software simulations)
 **Telecommunications**	Programming AI models to identify recurring customer concerns and deliver solutions before complaints arise
 **Pharmaceuticals and medical products**	Exploring relationships across different medical treatments and their combined outcomes for the discovery of new drugs
 **Aerospace and defense**	Aiding the design process (eg, through visual simulations of aircraft performance under different conditions) as well as for security and risk mitigation processes
 **Healthcare systems and services**	Enhancing healthcare services through functions like automated pathology recognition and diagnosis decision support
 **Financial services**	Supporting risk management in financial services, eg, detecting credit card fraud to reduce incidents of loss
 **Retail and consumer packaged goods**	Boosting sales by using ML to analyze huge sets of purchasing data, discern patterns, and give shoppers customized recommendations
 **Education**	Improving personalized learning based on students' progress
 **Aviation, travel, and logistics**	Leveraging multimodal fusion, enabled by AI, to combine inputs from various sensors that can help operate autonomous vehicles[2]

[1]Not exhaustive and focused on industries where AI has widespread applications with mature adoption.
[2]For more, see "Future of mobility," *McKinsey Technology Trends Outlook 2022*, McKinsey, Aug 2022.

Source: Expert input; McKinsey analysis

What industries are most affected by the trend? (continued)

A **diverse set of stakeholders** across all industries are experiencing implications from applied AI, which can include **disruption in value chains, better financial outcomes**, and **improved operations**

Industry affected[1]	Example impact from the trend
 **Agriculture**	Enabling process optimization through capabilities like productivity forecasting and driverless tractor applications
 **Automotive and assembly**	Automation of quality testing and manufacturing/assembly processes
 **Chemicals**	Optimizing chemical development and production cycles by recognizing molecules, generating chemical compound formulas, and analyzing chemical mixtures
 **Construction and building materials**	Using autonomous machinery and robots, computer-vision enhanced safety procedures, and 3-D design optimization software
 **Electric power, natural gas and utilities**	Optimizing energy production and scheduling, detecting equipment defects early to minimize downtime, and analyzing consumer energy use data to inform personalized recommendations
 **Metals and mining**	Increasing worksite process efficiencies and aiding the development of digital twins that can generate visualizations and models of remote sites
 **Oil and gas**	Exploration of site through computer vision to assess the value of holdings and use AI/ML to customize drilling plans for geologically-complex areas and forecast demand
 **Public and social sectors**	Leveraging AI/ML to expedite delivery of key services (eg, use of NLP for tax FAQ handling); additionally, AI/ML can be used as a tool to help in audit mechanisms to ensure the proper use of resources (eg, predictive tools to help focus tax auditing)
 **Real estate**	Providing personalized customer property recommendations, performing market analyses to help developers manage risk and price volatility, as well as optimizing ROI

[1]Nonexhaustive and focused on industries where AI has widespread applications with mature adoption.

Source: Expert input; McKinsey analysis

What are some use cases for applied AI?

Innovation led | Gaining business adoption

Use case[1]	Technology[2]	Function	Relevant industries[3]	Description	Benefits[4]
Generate 3-D models	Computer vision; ML *Optional:* NLP	Product development	Technology; manufacturing; consumer goods; retail	Apply generative techniques that synthesize 3-D visuals based on singular or multimodal instructions. *Examples:* Models for animation, furniture models, and apparel re-creations	Decrease cost with improved efficiency through quickly generated 3-D models
Prioritize dynamically changing tasks	ML; deep reinforce-ment learning *Optional:* Computer vision; NLP	Service operations	Any	Optimize changing workflow through multitask learning to prioritize most relevant tasks. *Examples:* Schedule-planning and project management tools	Decrease cost with improved productivity
Fuse multi-modal sensors	Deep reinforcement learning; ML; computer vision. *Optional:* NLP	Product development	Transportation; retail; healthcare	Utilize various sensor inputs to perform tasks. *Examples:* Sales checkout for retail; vehicle sensing for autonomous driving	Decrease cost by automating systems requiring sensor input
Recommend products to purchase	ML *Optional:* Knowledge graphs; NLP; computer vision	Product development	Technology; retail finance; healthcare	Predict and suggest potential products relevant to a customer's interests based on prior customer data (individuals or groups). *Examples:* Online suggestions of products to purchase; movie recommendations	Improve revenue through increased sales via personalized recommendations
Detect fraud	ML *Optional:* Knowledge graphs; NLP	Risk management	Any	Detect fraudulent behaviors to reduce incidents of loss. *Examples:* Detection of fraudulent credit card purchases and account log-in	Reduce losses through stronger detection of risky behaviors

[1]List of use cases is nonexhaustive and highlights those that are at the frontier of innovation and/or rapidly gaining adoption across organizations.
[2]Technologies typically used to implement the use case. Optional technologies can be applied but depend on the specific task for the use case.
[3]Relevant industries are nonexhaustive and highlight industries with visible adoption of the use case.
[4]Nonexhaustive benefits, focusing on major benefits to businesses.

Source: Expert input; McKinsey analysis

What should a leader consider when engaging with the trend?

Benefits

- **Cost savings:** Up to 90% of survey respondents cited cost decreases in 2020
- **Overall revenue increase:** Up to 75% of survey respondents cited revenue increases in 2020[1]
- **New use cases:** New use cases will unlock new business capabilities and opportunities across automation and acceleration
- **Increased access to AI and ease of implementation:** New technologies and practices, such as ML operations and software automation, should make AI more readily available

Risks and uncertainties

- **High up-front investment in talent and resources:** This creates a high barrier to entry related to developing AI and ML workflows for production[1]
- **Cybersecurity and privacy concerns:** Data risks and vulnerabilities are occurring across the technical AI workflow; 55% of survey respondents cite cybersecurity as a leading risk in their business in 2021 and are actively taking steps to mitigate it
- **Increasing regulation and compliance:** New legislation will affect the development of AI's direction
- **AI ethics:** Issues include responsibility, equity, fairness, and explainability

[1]For more about development of ML systems and tools, see "Industrializing machine learning," *McKinsey Technology Trends Outlook 2022*, McKinsey, Aug 2022.

Source: "The state of AI in 2021," McKinsey, Dec 8, 2021; Stanford HAI; McKinsey analysis

What are some topics of debate related to the trend?

1 Trustworthiness

What does it mean to apply trustworthy and responsible AI?

- Potential risks and concerns increase as AI use cases expand
- According to the EU Commission High-Level Expert Group on AI, responsible and trustworthy AI can be defined by abiding laws, incorporating ethics, and implementing technical and social robustness to mitigate potential harm
- The commission has developed 7 requirements for AI responsibility and trust: human agency and oversight; societal and environmental well-being; technical robustness and safety; privacy and data governance; transparency; accountability; and diversity, nondiscrimination, and fairness

2 Explainability

When is AI explainability needed?

- AI explainability looks at how well we can understand an AI model. Interest in this field is rising as models are growing increasingly complex and high-risk use cases (eg, disease diagnosis) are being explored
- According to Stanford University Human-Centered Artificial Intelligence (HAI), there are three types of AI: engineers' explainability (technically explains how the AI model works), causal explainability (explains why a model input leads to its output), and trust-inducing explainability (information that people need to trust and deploy a model)
- Depending on the situation, organizations may use one type of explainability, a combination of types, or all three types (eg, disease risk evaluation looks at all three types)

3 Applications prioritization

How might companies better determine which AI application provide the most benefit?

- Across industries and organizations, each applications of AI will impact different stakeholders in a unique way; understanding how AI impacts each stakeholder, the organization, and the ecosystem will be particularly important for leaders as they decide which AI applications to leverage
- Understanding what impact on a use case an AI application will have will be more essential in prioritization decisions for leaders as they build the capabilities to deploy and monitor AI at scale

4 Other risks

What are other areas of risk that are relevant?

- According to Stanford HAI, leading areas of risk for organizations include cybersecurity, regulatory compliance, explainability, individual privacy, organizational reputation, and equity and fairness
- While customers, shareholders, and regulators are calling for increased scrutiny on these topics, subjective topics (eg, privacy, equity, and fairness) are not high strategic priorities within organizations, as they lack resources and capabilities to fully understand and address these concerns

Source: European Commission High-Level Expert Group on Artificial Intelligence; expert interviews; Stanford HAI; McKinsey analysis

Additional resources

Knowledge center

QuantumBlack, AI by McKinsey

Related reading

The state of AI in 2021

The AI Index Report: Measuring trends in artificial intelligence

It’s time for businesses to chart a course for reinforcement learning