



CENTER FOR HOMELAND
DEFENSE AND SECURITY
NAVAL POSTGRADUATE SCHOOL



HSx: ARTIFICIAL INTELLIGENCE & MACHINE LEARNING



June 2017

CONTEXT: BROAD STROKES

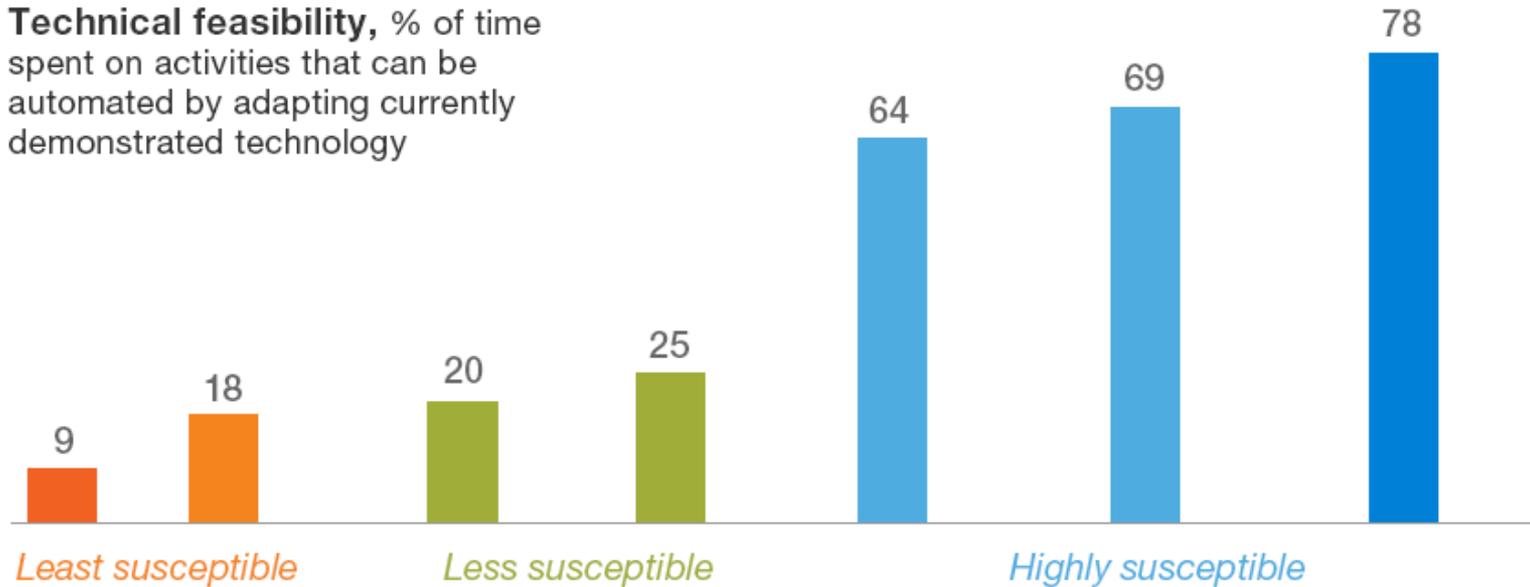
- Artificial intelligence (AI), automation, machine learning, and advances in robotics are being used to increase productivity, efficiency, and quality control while reducing operating and manufacturing costs.
 - In some fields, technology is augmenting human workforces, allowing for increased efficiency, and may increase employee satisfaction as robots take over strenuous, repetitive, or boring tasks.
 - In other fields, technology is replacing human workforces as careers become fully automated.
- AI, automation, robotics, and machine learning are creating new jobs including the design, sales, implementation, programming, and repair of these new technologies.

CONTEXT: BROAD STROKES (CONT.)

- AI, automation, robotics, and machine learning are being increasingly utilized; the rate of future adoption and capability improvement, however, is unclear.
- While the net impact of AI, automation, robotics, and machine learning is unclear, historically, technological advances have created more jobs than they have destroyed.
 - The benefits and consequences of AI, machine learning, robotics and automation depend on the level of aggregation (e.g., specific career, economic sector, national economy, etc.) and time scale (i.e., months, years, decades) at which the impact is evaluated.
 - Generally it is easier to estimate the negative impact of technology on employment opportunities than the positive impact.

CONTEXT: TECHNICAL POTENTIAL FOR AUTOMATION IN THE UNITED STATES BY TASK

Technical feasibility, % of time spent on activities that can be automated by adapting currently demonstrated technology



Time spent in all US occupations, %

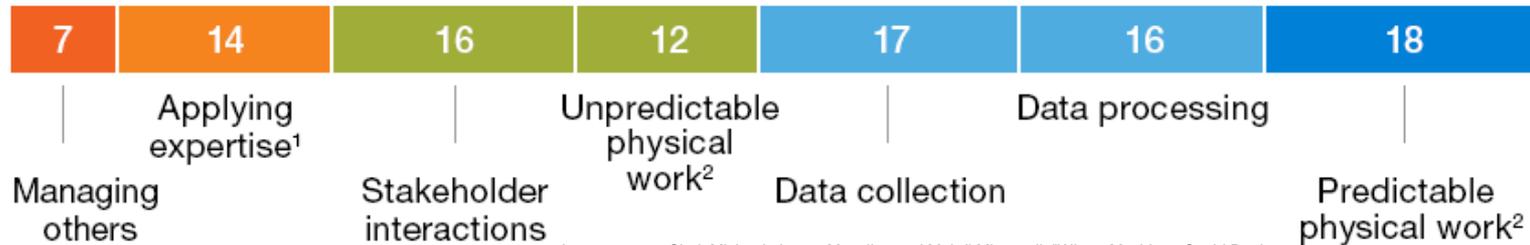


Image source: Chui, Michael, James Manyika, and Mehdi Miremadi. "Where Machines Could Replace Humans—And Where They Can't (Yet)." *McKinsey Quarterly* 7 (2016).

- Up to 47% of U.S. jobs could potentially be automated (i.e., technically feasible) within the next 10 to 20 years

CONTEXT: TECHNICAL POTENTIAL FOR AUTOMATION IN THE UNITED STATES BY SECTOR & TASK

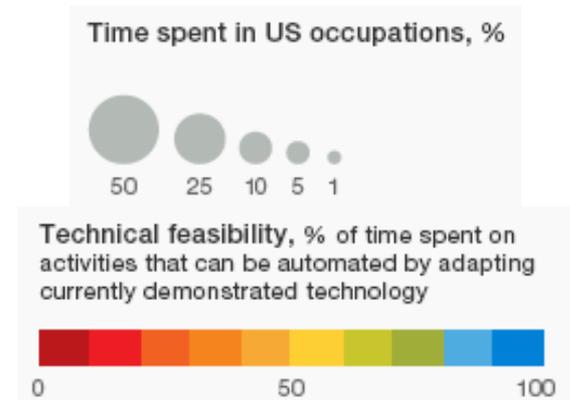
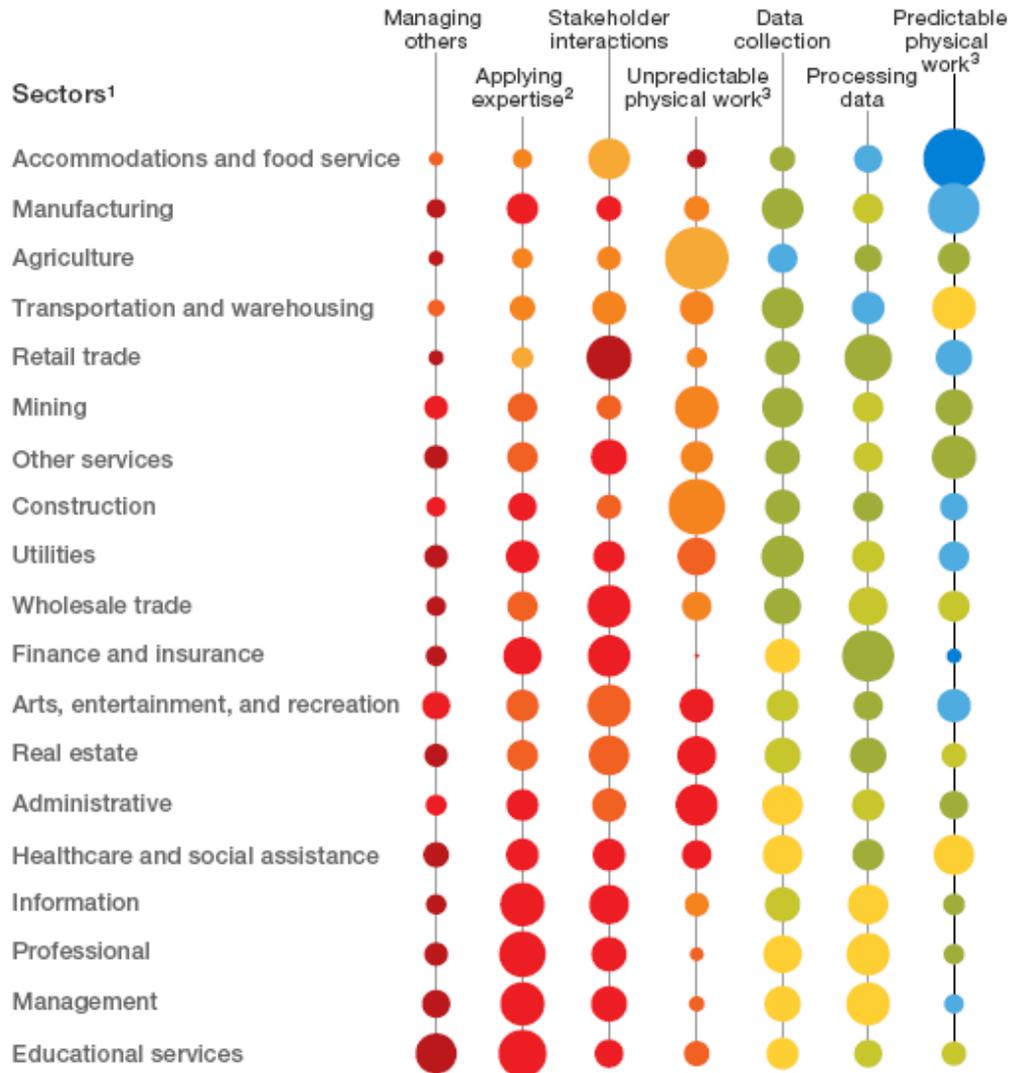


Image source: Chui, Michael, James Manyika, and Mehdi Miremadi. "Where Machines Could Replace Humans—And Where They Can't (Yet)." *McKinsey Quarterly* 7 (2016).

BACKGROUND: THE FOURTH INDUSTRIAL REVOLUTION

- The first industrial revolution began in the United Kingdom during the late 18th century and consisted of the advent of factories and mass production of goods.
- The second industrial revolution, known as the technological revolution, occurred during the late 19th century and early 20th century and was characterized by improvements in steam power and later electric power within factories that led to the assembly line, dramatically increasing the efficiency and speed of mass production.
- The third industrial revolution began during the middle of the 20th century and involved the transition from mechanical and analogue electrical technology to digital electronics and information technology.

BACKGROUND: THE FOURTH INDUSTRIAL REVOLUTION (CONT.)

- The world is currently entering the fourth industrial revolution, characterized by the digitalization of factories through the combination of digital technologies to enable small batch manufacturing and complete factory automation enabled by artificial intelligence, autonomous robotics, machine learning and other digital technology (e.g., 3D printing).
- Unlike the first and second industrial revolutions, which involved breaking complex tasks traditionally performed by a single artist into numerous steps performed by numerous people, the third and fourth industrial revolutions are reducing the number of low skill jobs and increasing the demand for high skill employees.

BACKGROUND: DEFINITIONS

- **Artificial Intelligence:** Artificial intelligence is a general term applied to machines that perform complex physical or cognitive tasks, react like humans and who would be considered intelligent if their work and reactions were exhibited by humans
 - Examples of AI include machine learning, image and speech recognition, deep learning, decision making, and natural language processing.
- **Machine Learning:** Machine learning is a method of data analysis that involves algorithms that allow computers to iteratively learn from data in order to recognize trends and patterns within datasets. Machine learning becomes more effective at recognizing trends and patterns with larger datasets.

BACKGROUND: ANNUAL GLOBAL SUPPLY OF INDUSTRIAL ROBOTS

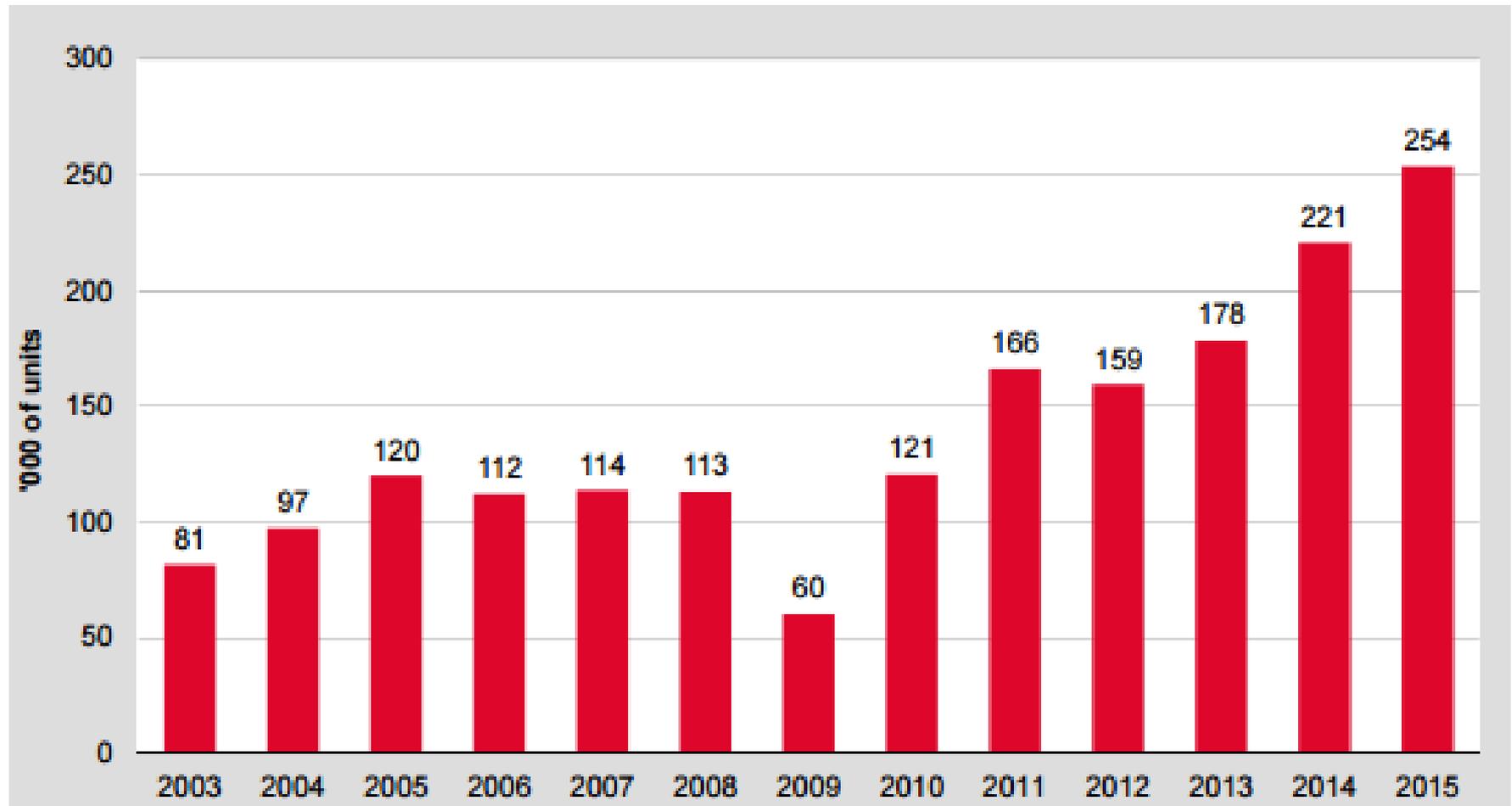
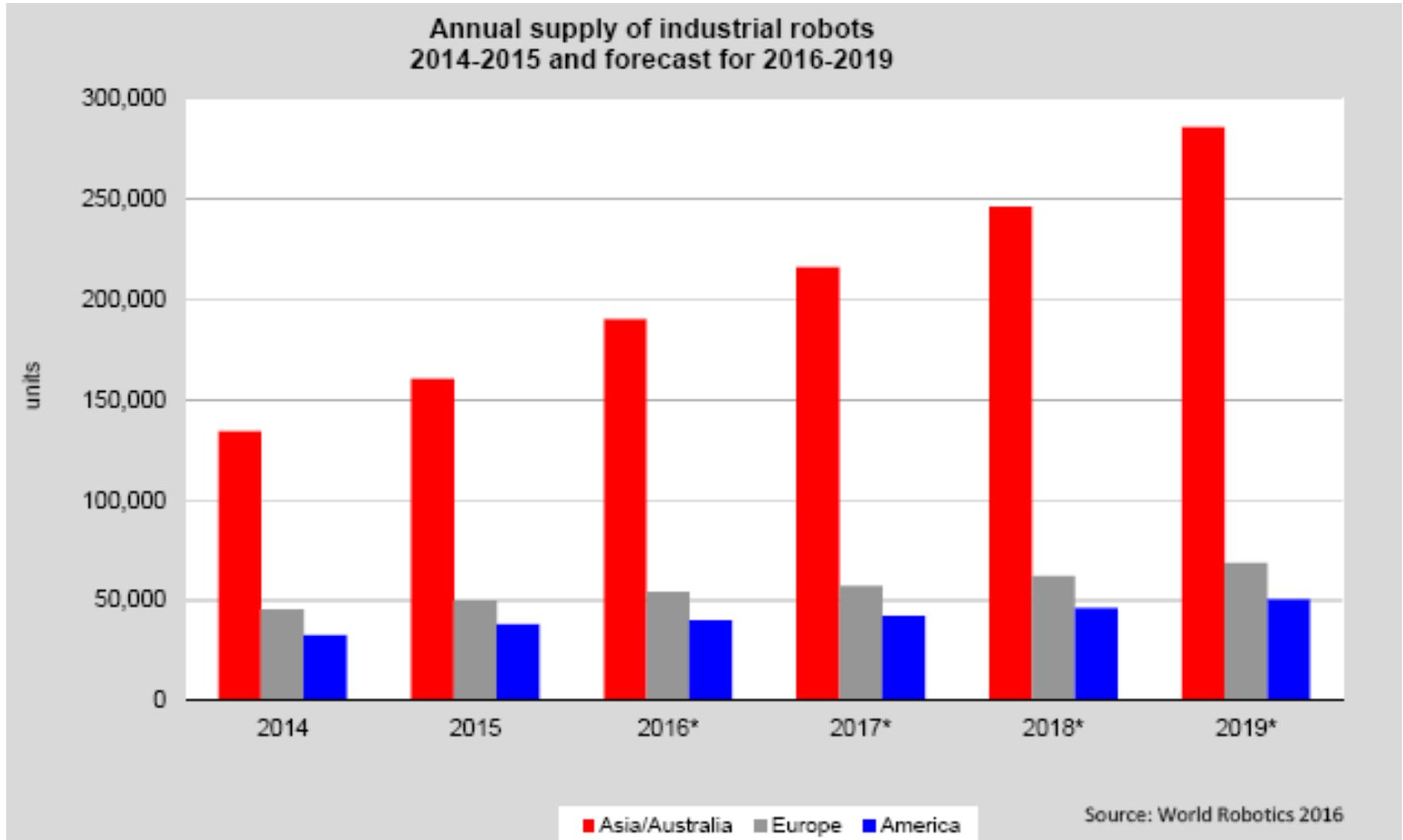


Image source: International Federation of Robotics. "Executive Summary World Robotics 2016 Industrial Robots." Accessed April 26, 2017.

- North American countries ordered 31,464 robots valued at \$1.8B in 2015

BACKGROUND: ANNUAL GLOBAL SUPPLY OF INDUSTRIAL ROBOTS BY REGION



BACKGROUND: ANNUAL INDUSTRIAL ROBOT SHIPMENTS BY REGION AND COUNTRY

Estimated yearly shipments of multipurpose industrial robots in selected countries. Number of units

Country	2014	2015	2016*	2019*
America	32,616	38,134	40,200	50,700
Brazil	1,266	1,407	1,800	3,500
North America	31,029	36,444	38,000	46,000
Rest of South America	321	283	400	1,200
Asia/Australia	134,444	160,558	190,200	285,700
China	57,096	68,556	90,000	160,000
India	2,126	2,065	2,600	6,000
Japan	29,297	35,023	38,000	43,000
Republic of Korea	24,721	38,285	40,000	46,000
Taiwan	6,912	7,200	9,000	13,000
Thailand	3,657	2,556	3,000	4,500
other Asia/Australia	10,635	6,873	7,600	13,200
Europe	45,559	50,073	54,200	68,800
Central/Eastern Europe	4,643	5,976	7,550	11,300
France	2,944	3,045	3,300	4,500
Germany	20,051	20,105	21,000	25,000
Italy	6,215	6,657	7,200	9,000
Spain	2,312	3,766	4,100	5,100
United Kingdom	2,094	1,645	1,800	2,500
other Europe	7,300	8,879	9,250	11,400
Africa	428	348	400	800
not specified by countries**	7,524	4,635	5,000	8,000
Total	220,571	253,748	290,000	414,000

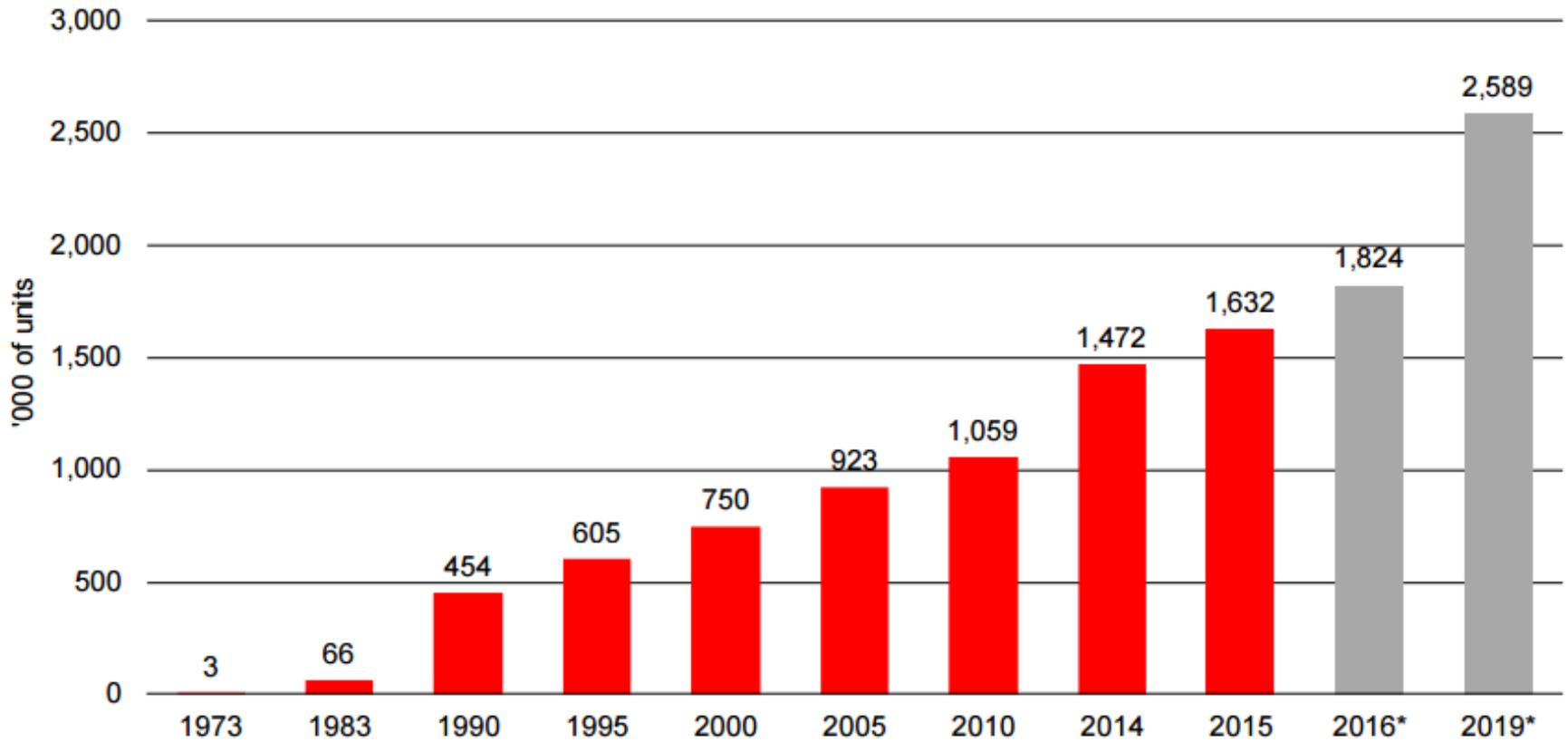
Sources: IFR, national robot associations.

Image source: International Federation of Robotics. "Executive Summary World Robotics 2016 Industrial Robots." Accessed April 26, 2017.

*forecast

** reported and estimated sales which could not be specified by countries

BACKGROUND: GLOBAL OPERATIONAL INDUSTRIAL ROBOT STOCK



*forecast

Image source: International Federation of Robotics. "Market Overview Presentation from the IFR World Robotics Press Conference." Accessed April 26, 2017.

Source: IFR World Robotics 2016

- The Robotic Industries Association estimates that around 260,000 industrial robots are operational in North American countries, behind only Japan and China

BACKGROUND: GLOBAL OPERATIONAL INDUSTRIAL ROBOT STOCK BY INDUSTRY

Estimated worldwide operational stock of industrial robots at year-end by main industries 2013 - 2015

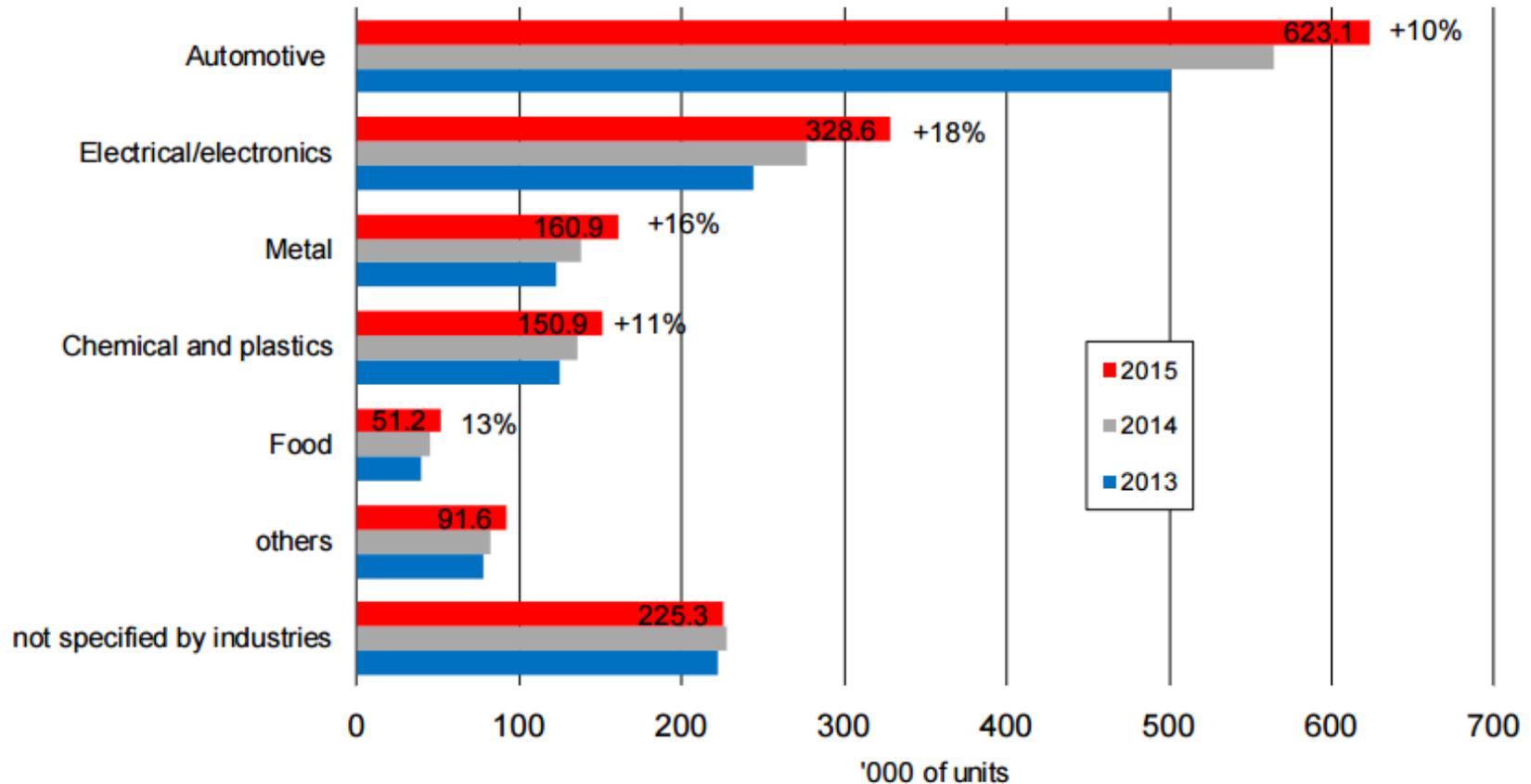


Image source: International Federation of Robotics. "Market Overview Presentation from the IFR World Robotics Press Conference." Accessed April 26, 2017.

Source: IFR World Robotics 2016

IMPLICATIONS OF AI, ROBOTICS, AUTOMATION, & MACHINE LEARNING: POLITICS

- Under- and unemployment associated with increasing utilization of AI and automation may dramatically increase the risk of social unrest.
- Advances in AI, machine learning, and other technology will increase the number of ways the public can interact with the government, serving to decentralize information and power.
- Similarly, advances in AI, machine learning, and other technology will provide new and improved methods for governments and law enforcement agencies to monitor, assess, mitigate, and control threats and individuals for political, social, or safety reasons and may lead to ethical issues regarding the utilization of these technologies
 - This will likely increase public distrust in the government and lead to increasing pressure from constituents to increase governmental transparency.

IMPLICATIONS OF AI, ROBOTICS, AUTOMATION, & MACHINE LEARNING: POLITICS (CONT.)

- Developments in AI, machine learning and robotics will have significant impact on national and international security, as these technologies act as a force multiplier and allow individuals to pose significantly greater threats than traditionally associated with non-state actors.
- Likewise, developments in AI, machine learning and robotics will dramatically change warfare and national conflicts (e.g., drones) like technological innovations have throughout history.

IMPLICATIONS OF AI, ROBOTICS, AUTOMATION, & MACHINE LEARNING: ECONOMY

- The net impact of AI, automation, robotics and machine learning on employment is unclear, and depends at which level the impact is evaluated.
 - Technological innovation inevitably leads to creative destruction as individuals, processes, or industries become obsolete.
 - At a specific occupation level, the human workforce may be completely replaced by AI, automation, robotics and machine learning, while at the sector level, some occupations may be eliminated while new occupations are created in the sector.
 - Historically, technological advances have enabled new types of work (often far beyond the intended application of the technology, especially when combined with other technology) that did not exist prior to the technological advancement and which would have been difficult if not impossible to predict prior to the advancement.
 - The secondary effects (e.g., customer savings, price elasticity [increased demand due to lower price point], profits for technology owners) associated with price decreases following the utilization of AI, automation, robotics and machine learning are critical for evaluating the net impact of technology adoption.

IMPLICATIONS OF AI, ROBOTICS, AUTOMATION, & MACHINE LEARNING: ECONOMY (CONT.)

- As AI, automation, robotics, and machine learning decrease the labor expenses of various goods and services, the price of these goods and services decreases.
 - As the price of a product or service decreases, it becomes more affordable, increasing demand for the product or service.
 - As the price of a product or service decreases, people already consuming that product or service will spend less money on their consumption, increasing their purchasing power and allowing them to spend the money saved on other goods or services, increasing demand for other goods and services.
 - This may provide the greatest benefit to low income individuals as decreasing living expenses allows for savings and discretionary spending.
- Because AI, automation, and machine learning are implemented to increase profits by reducing costs, it is likely their implementation will be dramatically slowed, potentially even reversed, if their implementation begins reducing customers' purchasing power and reducing profits.
- In addition to the cost savings through increased efficiencies and productivity, AI, robotics, automation, and machine learning help reduce business' risks by increasing quality control and reducing employee injuries, which may be significantly more valuable than the direct labor substitution.

IMPLICATIONS OF AI, ROBOTICS, AUTOMATION, & MACHINE LEARNING: ECONOMY (CONT.)

- Historically, individuals who have realized the greatest financial benefits from technological advances (e.g., factory owners, inventors) have invested their capital gains, thereby growing the economy and increasing employment opportunities.
 - Some research has suggested that the reinvestment of capital accumulation by owners of AI, automation, machine learning, and robotics may be significantly more critical to employment opportunities than machines supplanting the human workforce.
 - Increasing complexity of evaluation, unlike previous technological innovations that increased productivity or efficiency, AI, machine learning, robotics, and automation technologies are directly replacing human employees, eliminating the portion of the employee's income that would have gone into the economy.
- The human workforce in certain occupations are unlikely to ever become displaced, mainly in occupations requiring certain human qualities such as creativity, uniqueness/imperfection, empathy, and competition (athletics), as well as those occupations which require a high level of capital.

IMPLICATIONS OF AI, ROBOTICS, AUTOMATION, & MACHINE LEARNING: ECONOMY (CONT.)

- Historically, national economic growth has been associated with an increase in the number of jobs; however, beginning in 2000, this trend began weakening, likely at least in part due to increasing utilization of AI, automation, machine learning, and robotics.

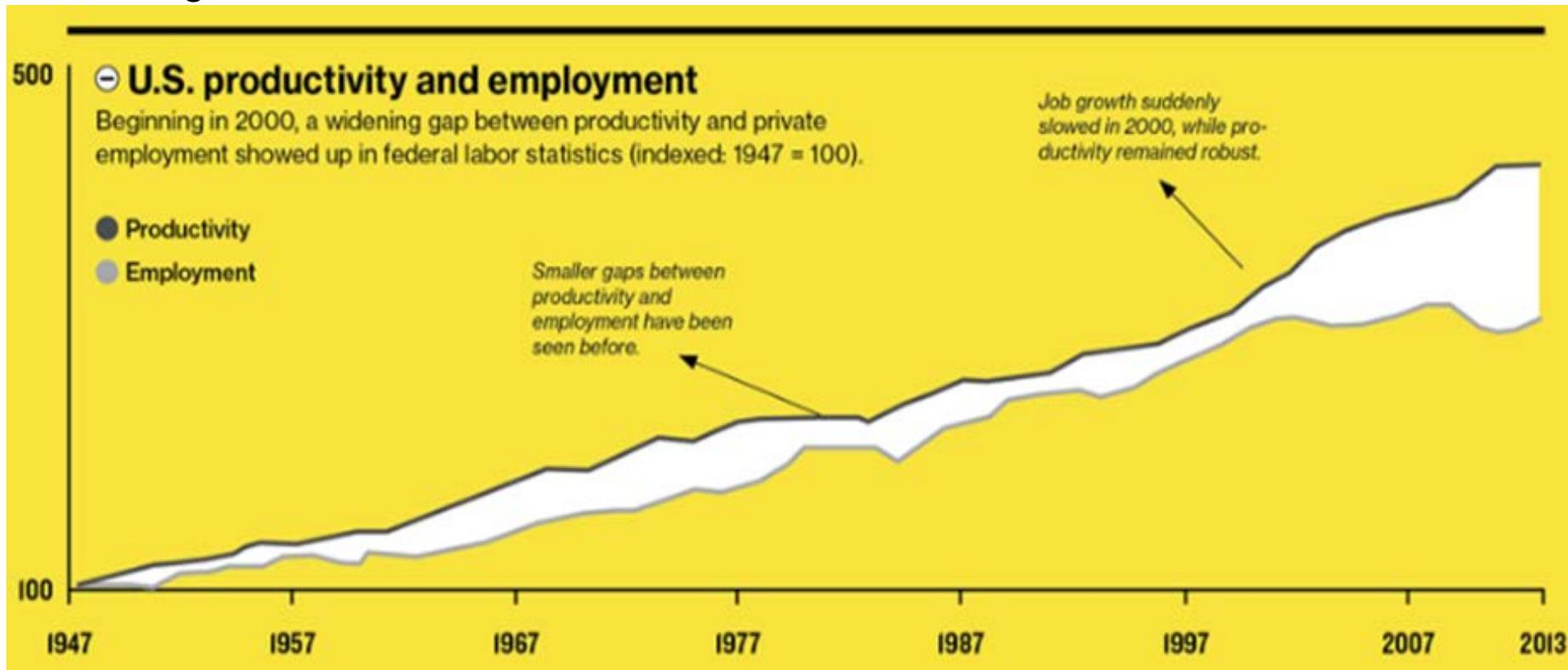


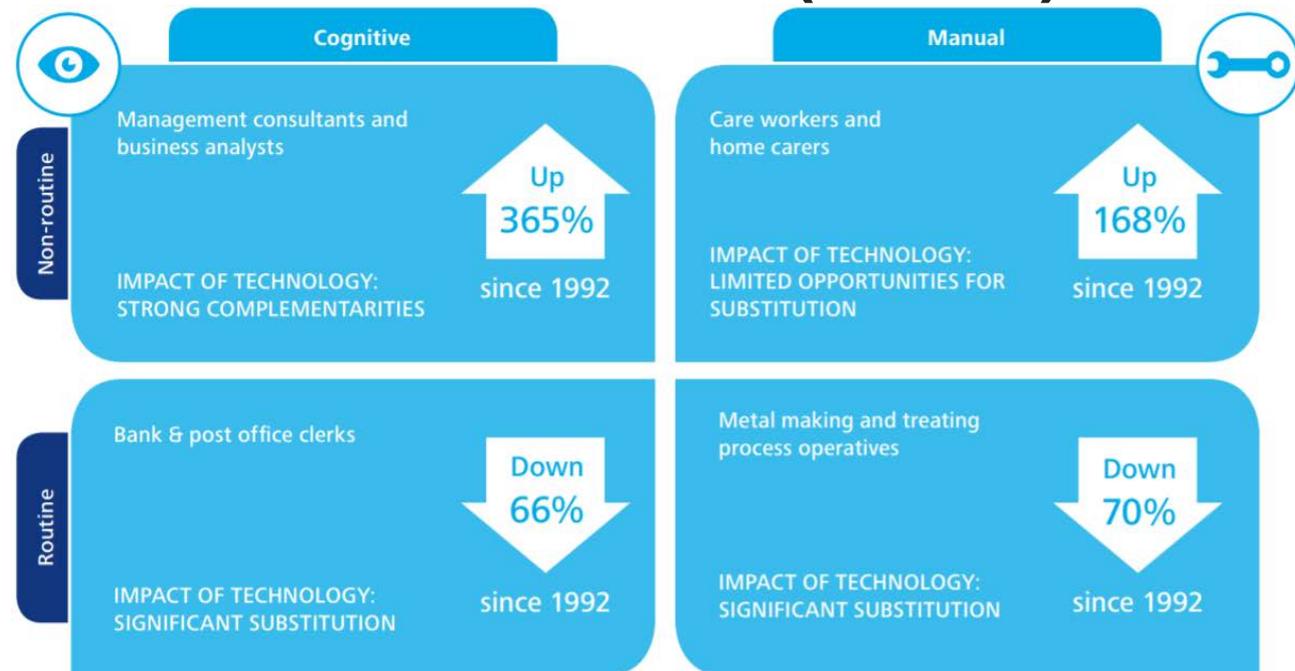
Image source: Rotman, David. "How Technology is Destroying Jobs." *MIT Technology Review* 116, no. 4 (2013).

IMPLICATIONS OF AI, ROBOTICS, AUTOMATION, & MACHINE LEARNING: ECONOMY (CONT.)

- As jobs within a particular sector are taken over by AI, automation, machine learning, and robotics, individuals who maintain their jobs within the same sector face stagnating or declining wages due to competition from the high supply of both the newly unemployed human workforce and the technology that replaced them.
- In addition to jobs being taken over by AI, automation, machine learning and robotics, it is likely that jobs in the future will be designed specifically for automation and robotics, shifting the impact from competing against the human workforce to monopolizing job activities.
- Robotics and AI will impact international trade and transportation; unlike the variations in labor costs throughout the world which have been a primary driver of international trade and outsourcing of manufacturing to cheap labor markets, robotics and AI will presumably cost the same to own and nearly the same to operate throughout the world, and thus will likely be used to satisfy local domestic demands in order to reduce transportation costs.
- In the future there may be a divergence of work tasks between humans and AI, with AI focused on efficiency, quality control, and repetitive tasks while the human workforce focuses on creativity and critical thinking.

IMPLICATIONS OF AI, ROBOTICS, AUTOMATION, & MACHINE LEARNING: ECONOMY (CONT.)

- Generally, occupations that involve highly repetitive/routine physical activities (typically blue collar occupations) have been the most susceptible to automation.
- It is expected that occupations involving highly repetitive/routine cognitive activities (typically white collar occupations) will be the next major group to become highly automated as these are relatively easy to automate and offer a higher labor cost reduction due to the relatively high salary of these occupations
 - Occupations involving non-repetitive/non-routine physical activities or non-repetitive/non-routine cognitive activities are difficult to automate due to the unpredictable nature of these occupations and have primarily benefited from advances in AI, automation, robotics, and machine learning.



IMPLICATIONS OF AI, ROBOTICS, AUTOMATION, & MACHINE LEARNING: SOCIETY

- As AI, automation, robotics, and machine learning replace segments of the human workforce, displaced individuals will require retraining and education to develop new skill sets for employment in different occupations. Displaced individuals will also need to develop increasing flexibility to adapt to changing work responsibilities as AI, automation, robotics, and machine learning continually redefine the responsibilities of occupations.
- The current educational system's focus on memorization and repetition of facts, processes, and tasks is not ideal for the job fluidity necessary for employees as increasing adoption of AI, automation, robotics, and machine learning continue to reshape the activities and responsibilities of various occupations.
 - A greater emphasis on creativity, curiosity, experimentation, flexibility, understanding of logic, and problem solving are necessary to enable employees to thrive as AI, automation, robotics, and machine learning continue to disrupt and redefine occupations.
 - Digital literacy may be as critical as reading literacy in the future.
- If in the distant future AI, automation, robotics, and machine learning replace nearly all employment opportunities, society will have the opportunity to redefine the social contract which for millennia has prescribed that people contribute to society through occupations.

IMPLICATIONS OF AI, ROBOTICS, AUTOMATION & MACHINE LEARNING: SOCIETY (CONT.)

- Increasing utilization of AI, machine learning, robotics, and automation could dramatically increase economic inequality as white collar employment opportunities are eliminated, forcing displaced employees to accept lower paying blue collar jobs while the salaries of individuals in occupations resistant to automation and those owning automation technologies continue to increase.
 - At the far extreme, if AI, automation, robotics, and machine learning replace a significant portion of the human workforce or job creation is unable to keep pace with job elimination, a growing segment of the population may be permanently unemployed.
- In addition to the economic benefits driving adoption of AI, automation, robotics, and artificial intelligence, convenience is becoming a major factor driving technology adoption (e.g., driverless cars, automated vacuums, building energy management systems, GPS).
- People may be less forgiving of mistakes by AI than by humans as AI errors will be seen as bad programming rather than misunderstanding.
- AI, machine learning, robotics, and automation may disproportionately impact older employees as they may be unable to shift their skill set to new career applications.

IMPLICATIONS OF AI, ROBOTICS, AUTOMATION & MACHINE LEARNING: SOCIETY (CONT.)

- There is a large segment of individuals who have a fear of, distrust of, hatred toward, or resistance to AI, robotics, machine learning, and automation.
 - Some people strongly fear AI, robotics, and automation will take their job, causing significant financial hardship and potential permanent unemployment.
 - Some people have a strong moral objection to artificial intelligence as they feel it conflicts with their religious beliefs.
 - Others may have a strong distrust of technology, whether due to misunderstanding the intent or capabilities of the technology or fearing the technology is being used to spy on them, both of which are commonly portrayed in various science fiction novels, movies, and television programs.
- AI, automation, robotics, and machine learning may increase employee satisfaction and reduce employee injuries as machines takeover strenuous, dull, or dangerous job tasks.
- Increasing utilization of AI and machine learning by individuals, organizations, and governments will have an strong negative impact on privacy, raising the ethical question of the right to privacy that will become more central as AI becomes more pervasive.

IMPLICATIONS OF AI, ROBOTICS, AUTOMATION & MACHINE LEARNING: SOCIETY (CONT.)

- As AI, automation, robotics, and machine learning become more widely utilized, there will be an ethical debate regarding the role and responsibility of employers, organizations, and governments to ensure sufficient job opportunities for individuals, potentially leading to a 'human-made' movement (similar to the current ethical debate over the past few decades regarding outsourcing jobs to lower wage countries leading to a 'American-made' movement).
- AI, automation, robotics, and machine learning will dramatically improve the health care system, leading to a highly personalized and increasingly accurate diagnoses and treatment plans based on a greater level of knowledge (through an aggregation of medical data, tests results, studies, etc.) than could be obtained by an individual doctor.
 - This will improve patient outcomes, expedite treatment, and reduce medical waste.
 - AI, automation, robotics, and machine learning will also accelerate drug research and development by both identifying the most likely drug compounds and by increasing the speed of the development process.

IMPLICATIONS OF AI, ROBOTICS, AUTOMATION & MACHINE LEARNING: TECHNOLOGY

- While it is clear that AI, automation, robotics, and machine learning are increasingly being utilized, the rate at which they will be adopted in the future and at what rate they will improve remains uncertain.
- While traditionally robotics and automation have been separated from human workspaces due to the inherent dangers, advances in AI have enabled the development of new smart, safe robots that augment the capabilities of human employees, leading to new robot-human teams that are more efficient than either all robot or all human workforces.

RESOURCES

- The following resources provide further information on this topic:
 - Smith, Aaron, and Janna Anderson. "AI, Robotics, and the Future of Jobs." *Pew Research Center* (2014).
 - Business.com Editorial Staff. "Watson Calling? The Impact of Artificial Intelligence on Business." *Business.com*. February 22, 2017.
 - Stewart, Ian, Debapratim De, and Alex Cole. "Technology and People: The Great Job-Creating Machine." *Deloitte, London: UK* (2015).
 - Pecorari, Maria. "3 Ways Business Leaders Can Use AI Ethically." *World Economic Forum*. January 13, 2017.
 - Chui, Michael, James Manyika, and Mehdi Miremadi. "Where Machines Could Replace Humans— And Where They Can't (Yet)." *McKinsey Quarterly* 7 (2016).
 - Knight, Will. "How Human-Robot Teamwork Will Upend Manufacturing." *MIT Technology Review* 117, no. 6 (2014).
 - Gregory, Terry, Anna Salomons, and Ulrich Zierahn. "Racing With or Against the Machine? Evidence from Europe." *Centre for European Economic Research*. (2016).
 - Rotman, David. "How Technology is Destroying Jobs." *MIT Technology Review* 116, no. 4 (2013).
 - Frey, Carl Benedikt, and Michael A. Osborne. "The Future of Employment: How Susceptible are Jobs to Computerisation?" *Technological Forecasting and Social Change* 114 (2017): 254-280.
 - Schwab, Klaus. "The Fourth Industrial Revolution: What it Means, How to Respond." *World Economic Forum*. January 14, 2016.
 - Robotic Industries Association. "North American Robotics Market Sets New Records in 2015." *Robotic Industries Association*. February 10, 2016.
 - International Federation of Robotics. "Executive Summary World Robotics 2016 Industrial Robots." *Accessed April 26, 2017*.

- **Additional research materials and information sources regarding this topic can be found in the associated *Literary & Scholastic Resource List*.**

Literary and Scholastic Resources –Artificial Intelligence and Machine Learning

Date of information: 5 June 2017

Overview: While not exhaustive, the following resources provide a roadmap to understanding the relationship between advancements and increasing utilization of artificial intelligence, robotics, automation, and machine learning, and the impact this will have on the economy and employment. These resources provide a baseline of understanding, but as the strategic environment continues to evolve, new data will become available and the resource list will require updates.

Module Resource Lists to Cross-Reference: Convergence of Terrorism & Transnational Crime, Managing Global Issues as Actors Multiply, Changing Role of the Individual, Role of Big Data

Organizations:

- **Pew Research Center:** The Pew Research Center is a nonprofit, nonpartisan organization that seeks to inform the public of and support sound decision-making based on trends, issues, and attitudes in national and international politics, science, religion, economics, and demography. <http://www.pewresearch.org/>
- **World Economic Forum:** The World Economic Forum is a nonprofit foundation that seeks to shape global, regional, and industrial agendas through engagement with political and business leaders throughout the world. <https://www.weforum.org/>
- **MIT Technology Review:** The MIT Technology Review is a media organization that aims to inform public knowledge and encourage contributions to the evolution of technology by publishing articles covering developments in technology and their impacts. <https://www.technologyreview.com/>
- **International Federation of Robotics:** The International Federation of Robotics (IFR) is a non-profit organization that conducts research on trends in robotics and markets utilizing robotics, stimulating robotics research and coordinating with other national and international robotics organizations. <https://ifr.org/>
- **Center for European Economic Research:** The Center for European Economic Research (ZEW) is a non-profit institute that focuses on research of European economies and institutions. <http://www.zew.de/en/>
- **Robotic Industries Association:** The Robotic Industries Association (RIA) is a robotics trade organization consisting of manufacturers, component suppliers, researchers, and consultants that seeks to drive innovation, growth, and safety within the robotics industry through education and advancement of robotics and automation technologies. <https://www.robotics.org/>
- **Oxford Martin School at the University of Oxford:** The Oxford Martin School is a research organization that invests in multidisciplinary research projects aimed at addressing global challenges. <http://www.oxfordmartin.ox.ac.uk/>

Recent Publications and Journal Articles:

- Race Against the Machine: How the Digital Revolution is Accelerating Innovation, Driving Productivity, and Irreversibly Transforming Employment and the Economy: This publication provides an overview of the impact of information technologies on employment opportunities, wages, employee skills, and the economy.
 - *Citation*: Brynjolfsson, Erik, and Andrew McAfee. *Race Against the Machine: How the Digital Revolution is Accelerating Innovation, Driving Productivity, and Irreversibly Transforming Employment and the Economy*. Brynjolfsson and McAfee, 2012.
http://digital.mit.edu/research/briefs/brynjolfsson_McAfee_Race_Against_the_Machine.pdf
- An Economy That Works: Job Creation and America's Future: This report examines employment trends in the United States following the 2008 economic recession with the goal of projecting future job creation and the changing nature of employment in the United States.
 - *Citation*: Manyika, James, Susan Lund, Byron Gerald Augustine, Lenny Mendonca, Tim Welsh, and Sreenivas Ramaswamy. *An Economy That Works: Job Creation and America's Future*. 2011.
http://www.mckinsey.com/~media/McKinsey/Global%20Themes/Employment%20and%20Growth/An%20economy%20that%20works%20for%20US%20job%20creation/MGI_US_job_creation_full_report.ashx
- The Future of Employment: How Susceptible are Jobs to Computerisation?: This report examines the susceptibility of over 700 distinct U.S. occupations to automation (in terms of a probability of automation), drawing conclusions about how susceptible various occupations are to automation based on average wages and educational attainment of employees in each occupation.
 - *Citation*: Frey, Carl Benedikt, and Michael A. Osborne. "The Future of Employment: How Susceptible are Jobs to Computerisation?" *Technological Forecasting and Social Change* 114 (2017): 254-280.
http://www.oxfordmartin.ox.ac.uk/downloads/academic/The_Future_of_Employment.pdf
- Racing With or Against the Machine? Evidence from Europe: This ZEW report examines the economy-wide impact of technology replacing employment in Europe, considering the impact of technology replacing labor, the associated decreased costs of products and services associated with automation, and the increased investment of accrued capital by individuals owning robotics and automation technologies.
 - *Citation*: Gregory, Terry, Anna Salomons, and Ulrich Zierahn. "Racing With or Against the Machine? Evidence from Europe." *Centre for European Economic Research*. (2016).
<http://ftp.zew.de/pub/zew-docs/dp/dp16053.pdf>
- How Technology is Destroying Jobs: This MIT Technology Review journal article provides an overview of artificial intelligence, robotics, and automation, with a particular focus on historical economic, employment, and job sectors trends, projecting the impact increased automation will have on all three.
 - *Citation*: Rotman, David. "How Technology is Destroying Jobs." *MIT Technology Review* 116, no. 4 (2013). <https://www.technologyreview.com/s/515926/how-technology-is-destroying-jobs/>
- How Human-Robot Teamwork Will Upend Manufacturing: This MIT Technology Review journal article examines the new trend of robots working along with humans to enable humans to more effectively and efficiently execute job responsibilities.
 - *Citation*: Knight, Will. "How Human-Robot Teamwork Will Upend Manufacturing." *MIT Technology Review* 117, no. 6 (2014). <https://www.technologyreview.com/s/530696/how-human-robot-teamwork-will-upend-manufacturing/>
- Where Machines Could Replace Humans—And Where They Can't (Yet): This McKinsey Quarterly article examines the automation potential of over 2,000 work activities from over 800 occupations, drawing conclusions about the automation potential across 8 work activity categories and 19 industries.

- *Citation:* Chui, Michael, James Manyika, and Mehdi Miremadi. “Where Machines Could Replace Humans—And Where They Can’t (Yet).” *McKinsey Quarterly* 7 (2016).
<http://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/where-machines-could-replace-humans-and-where-they-cant-yet>
- The Technology Revolution and the Restructuring of the Global Economy: This article examines the impact rapid technological innovation, digital electronics, and information technology has on the global economy, economic growth, and globalization.
 - *Citation:* Colombo, Umberto. “The Technology Revolution and the Restructuring of the Global Economy.” *Globalization of Technology: International Perspectives* (1988): 23-31.
<https://www.nap.edu/read/1101/chapter/4>
- The Next Production Revolution: Key Issues and Policy Proposals: This article discusses some of the broad impacts advances in technology, artificial intelligence, machine learning, and robotics are having on manufacturing and productivity, and how this impact will evolve in the future.
 - *Citation:* Nolan, Alistair. “The Next Production Revolution: Key Issues and Policy Proposals”, in *The Next Production Revolution: Implications for Governments and Business*. OECD Publishing, Paris. (2017). http://www.oecd-ilibrary.org/science-and-technology/the-next-production-revolution/the-next-production-revolution-key-issues-and-policy-proposals_9789264271036-5-en
- AI, Robotics, and the Future of Jobs: This Pew Research Center report provides highlights from and analysis of survey responses from over 2,500 technology and internet experts on the impact technology, robotics, and automation will have on the employment by 2025.
 - *Citation:* Smith, Aaron, and Janna Anderson. “AI, Robotics, and the Future of Jobs.” *Pew Research Center* (2014). <http://www.pewinternet.org/files/2014/08/Future-of-AI-Robotics-and-Jobs.pdf>

Other Resources:

- Technology and People: The Great Job-Creating Machine: This Deloitte report provides a historical examination of the impact of technology on employment over the past 150 years in England and Wales, with the goal of assessing the ways in which technology has continually evolved employment, particularly examining the ways in which technology has created new economic sectors and revolutionized existing sectors in ways that would have been difficult to predict.
 - *Citation:* Stewart, Ian, Debapratim De, and Alex Cole. “Technology and People: The Great Job-Creating Machine.” *Deloitte, London: UK* (2015).
<https://www2.deloitte.com/content/dam/Deloitte/uk/Documents/finance/deloitte-uk-technology-and-people.pdf>
- Executive Summary World Robotics 2016 Industrial Robots: This executive summary from the IFR World Robotics 2016 report provides information on global trends within the robotics field, specifically providing information on sales and deliveries of robotics to major economic sectors and countries.
 - *Citation:* International Federation of Robotics. “Executive Summary World Robotics 2016 Industrial Robots.” *Accessed April 26, 2017*.
https://ifr.org/img/uploads/Executive_Summary_WR_Industrial_Robots_20161.pdf
- Market Overview Presentation from the IFR World Robotics Press Conference: This presentation from the IFR World Robotics Press Conference provides highlights from the IFR World Robotics 2016 report.
 - *Citation:* International Federation of Robotics. “Market Overview Presentation from the IFR World Robotics Press Conference.” *Accessed April 26, 2017*.
https://ifr.org/downloads/press/02_2016/Presentation_market_overviewWorld_Robotics_29_9_2016.pdf

- **Amplifying Human Potential: Towards Purposeful Artificial Intelligence (CEO Report):** This Infosys publication focuses on the impact of robotics and automation on employment and businesses, identifying obstacles to appreciating the fullest potential of robotics and automation in industry and suggesting actions for organization to take to be successful as automation and robotics revolutionize modern businesses.
 - *Citation:* Infosys Limited. “Amplifying Human Potential: Towards Purposeful Artificial Intelligence (CEO Report).” *Infosys Limited, Bengaluru: India* (2017).
<https://www.infosys.com/aimaturity/Documents/amplifying-human-potential-CEO-report.pdf>
- **Artificial Intelligence Doesn’t Just Cut Costs, It Expands Business Brainpower:** This Forbes article discusses the current benefits and potential future benefits of artificial intelligence for businesses.
 - *Citation:* McKendrick, Joe. “Artificial Intelligence Doesn’t Just Cut Costs, It Expands Business Brainpower.” *Forbes.com*. January 24, 2017.
<https://www.forbes.com/sites/joemckendrick/2017/01/24/artificial-intelligence-doesnt-just-cut-costs-it-expands-business-brainpower/#2724d55b535a>
- **How to Build an Inclusive Future in the Time of AI:** This article, prepared for the World Economic Forum Annual Meeting 2017, focuses on four areas in which business leaders should focus in order to ensure an inclusive work environment and a productive workforce in the future.
 - *Citation:* Sikka, Vishal. “How to Build an Inclusive Future in the Time of AI.” *World Economic Forum*. January 16, 2017. <https://www.weforum.org/agenda/2017/01/how-to-build-an-inclusive-future-in-the-time-of-ai>
- **The Fourth Industrial Revolution: What it Means, How to Respond:** This World Economic Forum article focuses on the fourth industrial revolution, the digital revolution, the challenges and opportunities of the digital revolution, and its current and future impact on society, business, employment, and government.
 - *Citation:* Schwab, Klaus. “The Fourth Industrial Revolution: What it Means, How to Respond.” *World Economic Forum*. January 14, 2016.
<https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond/>
- **North American Robotics Market Sets New Records in 2015:** This press release provides information on the sales and shipments of industrial robots in North America during 2015.
 - *Citation:* Robotic Industries Association. “North American Robotics Market Sets New Records in 2015.” *Robotic Industries Association*. February 10, 2016. https://www.robotics.org/content-detail.cfm?content_id=5951
- **3 Ways Business Leaders Can Use AI Ethically:** This article, prepared for the World Economic Forum Annual Meeting 2017, focuses on goals for business leaders to capitalize on advances in artificial intelligence and machine learning.
 - *Citation:* Pecorari, Maria. “3 Ways Business Leaders Can Use AI Ethically.” *World Economic Forum*. January 13, 2017. <https://www.weforum.org/agenda/2017/01/3-ways-business-leaders-can-use-ai-ethically>
- **The Future is Automated. Here’s How We Can Prepare for It:** This article, prepared for the World Economic Forum Annual Meeting 2017, focuses on ways businesses and employees are beginning to utilize and correspondingly adapt business practices and work activities as automation and artificial intelligence are implemented.
 - *Citation:* Miscovich, Peter. “The Future is Automated. Here’s How We Can Prepare for It.” *World Economic Forum*. January 12, 2017. <https://www.weforum.org/agenda/2017/01/the-future-is-automated-here-s-how-we-can-prepare-for-it>

- **Smart Robots Can Now Work Right Next to Auto Workers:** This MIT Technology Review article provides an overview of how robots are working alongside humans in a South Carolina BMW plant.
 - *Citation:* Knight, Will. “Smart Robots Can Now Work Right Next to Auto Workers.” *MIT Technology Review*. September 17, 2013. <https://www.technologyreview.com/s/518661/smart-robots-can-now-work-right-next-to-auto-workers/>

- **2017 is the Year Healthcare Goes Sci-Fi:** This article, prepared for the World Economic Forum Annual Meeting 2017, focuses on the impact that artificial intelligence and machine learning are currently having and will have in the future on health care.
 - *Citation:* Tas, Jeroen. “2017 is the Year Healthcare Goes Sci-Fi.” *World Economic Forum*. January 11, 2017. <https://www.weforum.org/agenda/2017/01/2017-is-the-year-healthcare-goes-sci-fi>

- **Agiletown: The Relentless March of Technology and London’s Response:** This Deloitte report examines the susceptibility of various occupations to automation in the United Kingdom, particularly in London.
 - *Citation:* Knowles-Cutler, Angus, Carl Frey, and Michael Osborne. “Agiletown: The Relentless March of Technology and London’s Response.” *Deloitte: London: UK*. (2014). <https://www2.deloitte.com/content/dam/Deloitte/uk/Documents/uk-futures/london-futures-agiletown.pdf>

- **The Third Industrial Revolution:** This article provides an overview of the next major industrial revolution as digital technologies, artificial intelligence, and robotic begin revolutionizing the world.
 - *Citation:* The Economist. “The Third Industrial Revolution.” *The Economist*. April 21, 2012. <http://www.economist.com/node/21553017>

- **Watson Calling? The Impact of Artificial Intelligence on Business:** This article discusses some current, well-known applications of artificial intelligence with a brief description of how artificial intelligence may impact employment in the future.
 - *Citation:* Business.com Editorial Staff. “Watson Calling? The Impact of Artificial Intelligence on Business.” *Business.com*. February 22, 2017. <https://www.business.com/articles/watson-calling-the-impact-of-artificial-intelligence-on-business/>