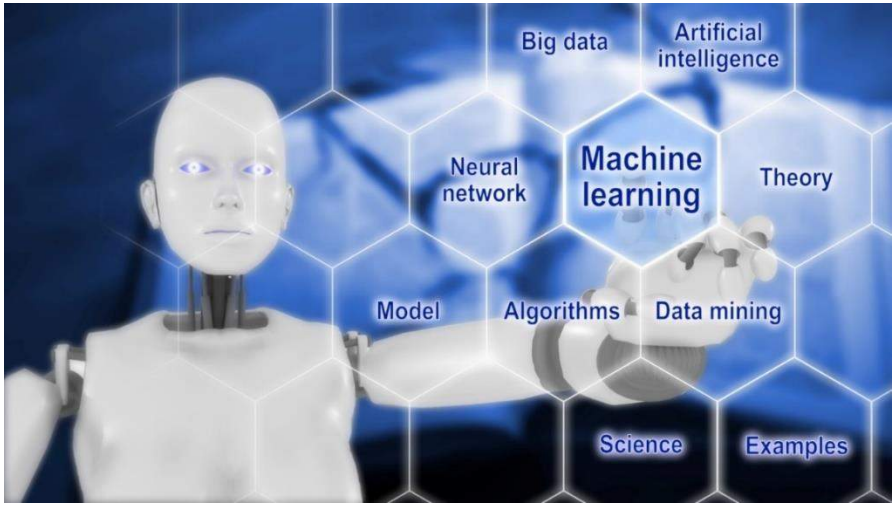
Future of Work

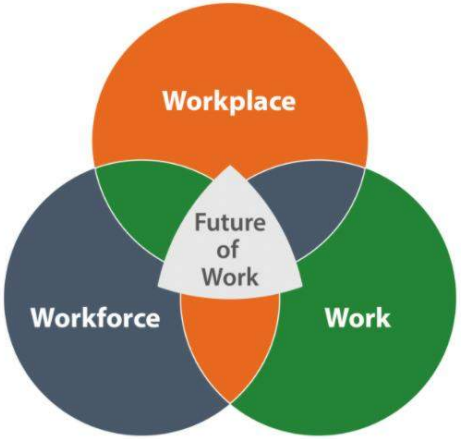


John Howard
National Institute for Occupational Safety and Health
Centers for Disease Control and Prevention
U.S. Department of Health and Human Services

9 March 2021
2021 Professional Development Conference
ASSP—San Diego Chapter

NIOSH Future of Work Initiative

https://www.cdc.gov/niosh/topics/future-of-work/default.ht



- Compile studies on the future of work
- Feature current and relevant research projects
- Promote research into:
  - New industries, technologies, organizational design, job arrangements, risk profiles, and ways to control risks
- Connect trends in workplace, work, and workforce to prepare for the future of occupational safety and health

CDC/NIOSH Future of Work Initiative Priority Topics

Issues that Impact Workplace, Work, and Workforce

Emergency and Disaster Preparedness and Response • Exposures and Hazards • Extreme Weather Conditions • Globalization • Industry 4.0 • OSH 4.0 • Policies • Politics • Resources • Social Disruption

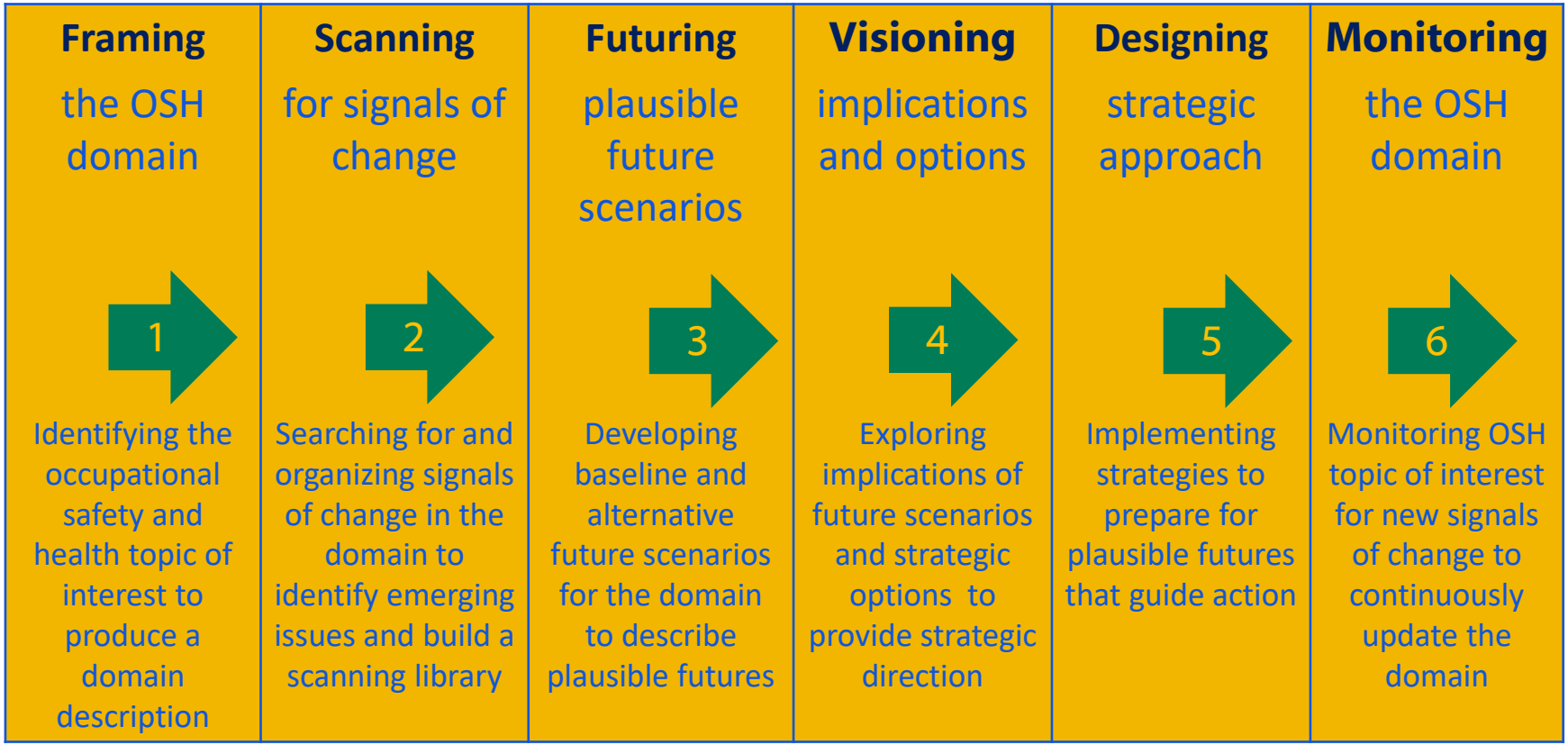
WORKPLACE	
ORGANIZATIONAL DESIGN	Autonomy • Burnout and Stress Prevention • Healthy Leadership • Job Flexibility • Leave Systems • Scheduling • Social and Corporate Responsibility • Workplace Built Environment • Workspace • Work-Life Fit
TECHNOLOGICAL JOB DISPLACEMENT	Automation • Digitalization • Job Quantity and Quality • Occupational Polarization • Productivity Enhancement and Quality Improvement through Automated Manufacturing • Stable, New, and Redundant Work
WORK ARRANGEMENTS	Alternative • App-Based • Contingent • Contractual • Direct Hire • Distributed • Free-Lancer • Job Sharing • Non-Standard • On-Call • On-Demand • Part-Time • Platform • Precarious • Seasonal • Single vs. Multi-Employers • Temporary
WORK	
ARTIFICIAL INTELLIGENCE	Deep Learning • Machine Learning • Neural Networks
ROBOTICS	Autonomous, Collaborative, Industrial, Managerial, Service, and Social Robots • Autonomous Vehicles • Human-Machine Interaction • Unmanned Aerial Systems • Wearable Exoskeletons and Exosuits
TECHNOLOGIES	Additive and Smart Manufacturing, and 3D Printing • Advanced, Cloud, and Quantum Computing • Bio-Manufacturing • Bio-Technology • Clean and Green Technologies • Digitalization • Information and Communication Technologies • Internet-of-Things • Nanotechnology and Advanced Materials • Sensors • Sensor Surveillance • Smart Personal Protective Equipment
WORKFORCE	
DEMOGRAPHICS	Diversity and Inclusivity • Multi-Generational • Productive Aging • Vulnerable
ECONOMIC SECURITY	Adequate Wages • Equitable and Commensurate Compensation and Benefits • Minimum Guaranteed Hours
SKILLS	Continual Education, Learning, and Training • Re-Skilling and Up-Skilling

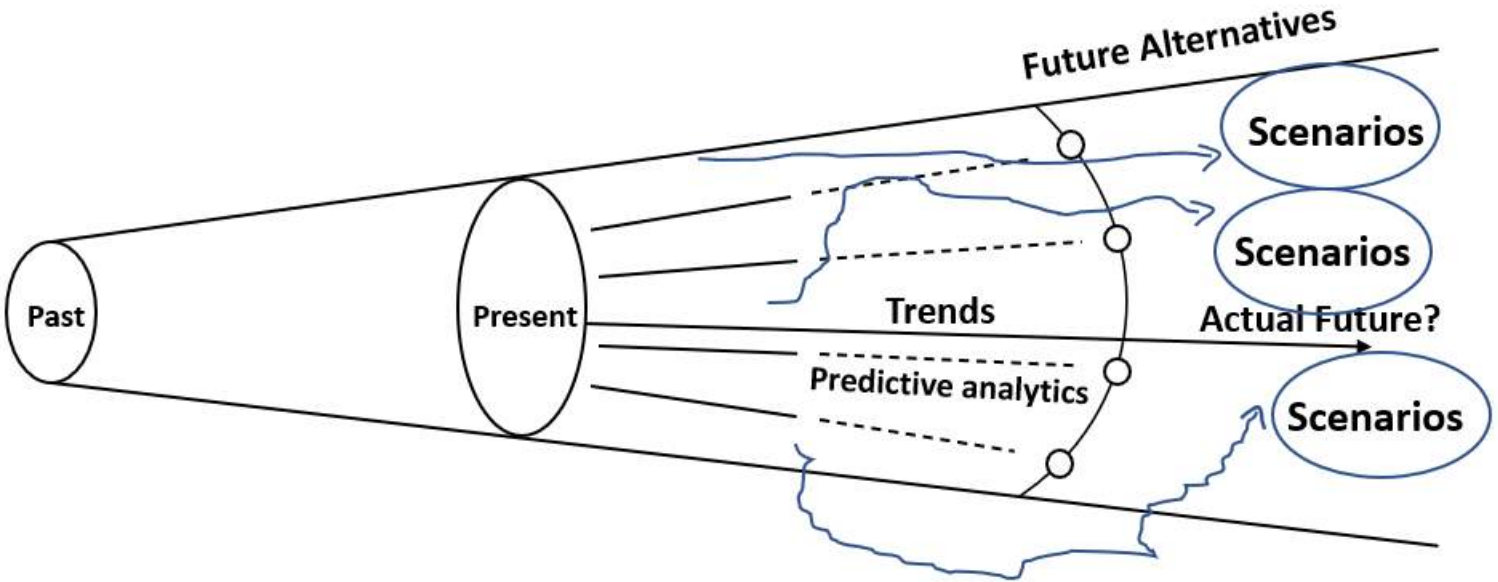
Strategic Foresight: A Future Thinking Tool

Strategic Foresight

- Results can guide policy, develop strategy, stimulate innovation and actions
- Being surprised = inadequate preparation
- Growing worldwide community of organizations and agencies employing strategic foresight

Framework for *Futuring*





(Adapted from Hines and Bishop 2007)

Future of Work Overview

- **Workplace**
  - Organizational Design
  - Work Arrangements
- **Work**
  - Robotics & Exoskeletons
  - Artificial Intelligence
- **Workforce**
  - Skills Gap
  - Automation

Workplace

Organizational Design

Work Arrangements

Organizational Design

- Rise of the Hybrid Workplace
  - Frequency of jobs with a fixed schedule, a dedicated location, and direct control by a single employer has decreased. Much work is becoming more distributed, and more virtual.

- The COVID-19 pandemic has shown the need for preparedness at the same time it has led to a "*tech-celeration*." New tech behaviors adopted during the pandemic will outlast it.

- Information communication technologies (ICTs) have radically shifted the design of workplaces:
  - Use of ICTs such as Wi-Fi-enabled laptops, smartphones, and tablets make it possible to complete many jobs from nearly anywhere at practically any time of day.
  - As a result, remote work, telework, and virtual teams have become accepted ways of working.
    - Approximately 20% of U.S. workers were engaging in remote or mobile work at least some of the time pre-COVID-19, and the frequency and regularity of this type of work is anticipated to grow
    - New ICT-enabled jobs.
      - Zoom, WebEx, Adobe Connect, Blue Jeans, Skype. Microsoft Teams

Organizational Design Research Yields Mixed Results

- **Positive**
  - Flexible workplaces and work schedules may result in increased job performance, job satisfaction, autonomy, and creativity. The increased utilization of remote work may also yield new employment opportunities for disadvantaged groups, such as those living with disabilities.

- **Negative**
  - Jobs consisting primarily of remote work may blur the boundaries between work and personal life, thereby increasing work–family conflict and work-related stress.
  - As ICT use intensifies and extended work availability becomes normalized, workers may also experience *telepressure*, an unhealthy internal state characterized by a constant preoccupation with work that is associated with increased burnout, elevated stress levels, and poor sleep practices.

Work Arrangements

- **Employment Relationship (Employee)**
  - Organization has directive control:
    - **Standard employment relationship—one** employer—one employee
    - **Temporary or co-employment—two** employers (staffing agency and client)—one employee

- **Business Relationship (Independent Contractor)**
  - Organization lacks directive control
  - **Business relationship** exists
    - Specifies the *what,* the *when,* but not the *how*
    - No employer and no employees—entrepreneurial contract

- **Gig or Platform Work (Worker)**
  - **Platform**—provider—customer
  - Is there directive control? Is the worker an independent contractor or an employee?
  - Common tasks—personal transport, delivery, household, and various micro tasks

Safety Net for Employees

- Old-age assistance and disability benefits
  - Social Security Act of 1935
- Collective bargaining rights
  - National Labor Relations Act, 1935
- Minimum wage, overtime and child labor protections
  - Fair Labor Standards Act, 1938
- Employment discrimination protections
  - Title VII of the Civil Rights Act, 1964
  - Age Discrimination in Employment Act, 1967
  - Americans with Disabilities Act, 1990
- Workplace safety and health protections
  - **Occupational Safety and Health Act, 1970**
- Pension, health and other employee benefits
  - Employee Retirement Income Security Act, 1974
  - Family Medical Leave Act of 1993
- Unemployment insurance and workers compensation benefits
  - Various Federal and state laws

Gig Economics: On the Upside Side

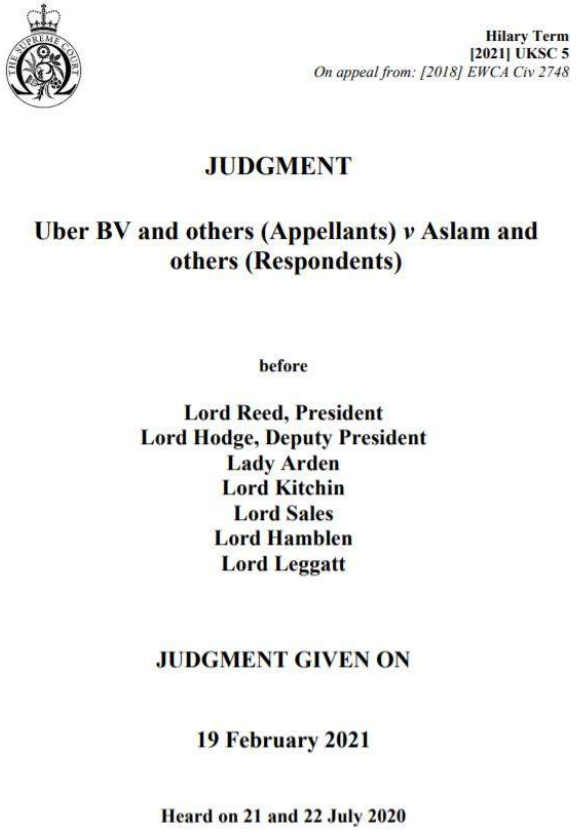
- Creates surplus value in the economy
- Faster matching customer demand and worker supply
- Platform removes transaction hassles
- Lowers costs associated with a permanent workforce

Gig Economics: On the Downside Side

- **Post-industrial corporation**
  - Maximize profits, but not through productive enterprise
- **Evasion of standard employment law**
  - Classifying workers as contractors allows platforms to offer services without having to pay for the direct and indirect costs of employment
- **Negative externalities**
  - Who pays to prevent, or to care for, workplace injuries or illnesses?
  - Devolves safety and health responsibilities to *“micro-entrepreneurs”*

Employee or Not Employee—U.S. and U.K

- California Proposition 22 (November 2020)
  - Exempts App-Based Transportation and Delivery Companies from Providing Employee Benefits to Certain Drivers.
  - Classifies drivers for app-based transportation (rideshare) and delivery companies as “independent contractors,” not “employees,” unless company sets drivers’ hours, requires acceptance of specific ride and delivery requests, or restricts working for other companies.



Hilary Term
[2021] UKSC 5
On appeal from: [2018] EWCA Civ 2748

JUDGMENT

Uber BV and others (Appellants) *v* Aslam and others (Respondents)

before

Lord Reed, President
Lord Hodge, Deputy President
Lady Arden
Lord Kitchin
Lord Sales
Lord Hamblen
Lord Leggatt

JUDGMENT GIVEN ON

19 February 2021

Heard on 21 and 22 July 2020

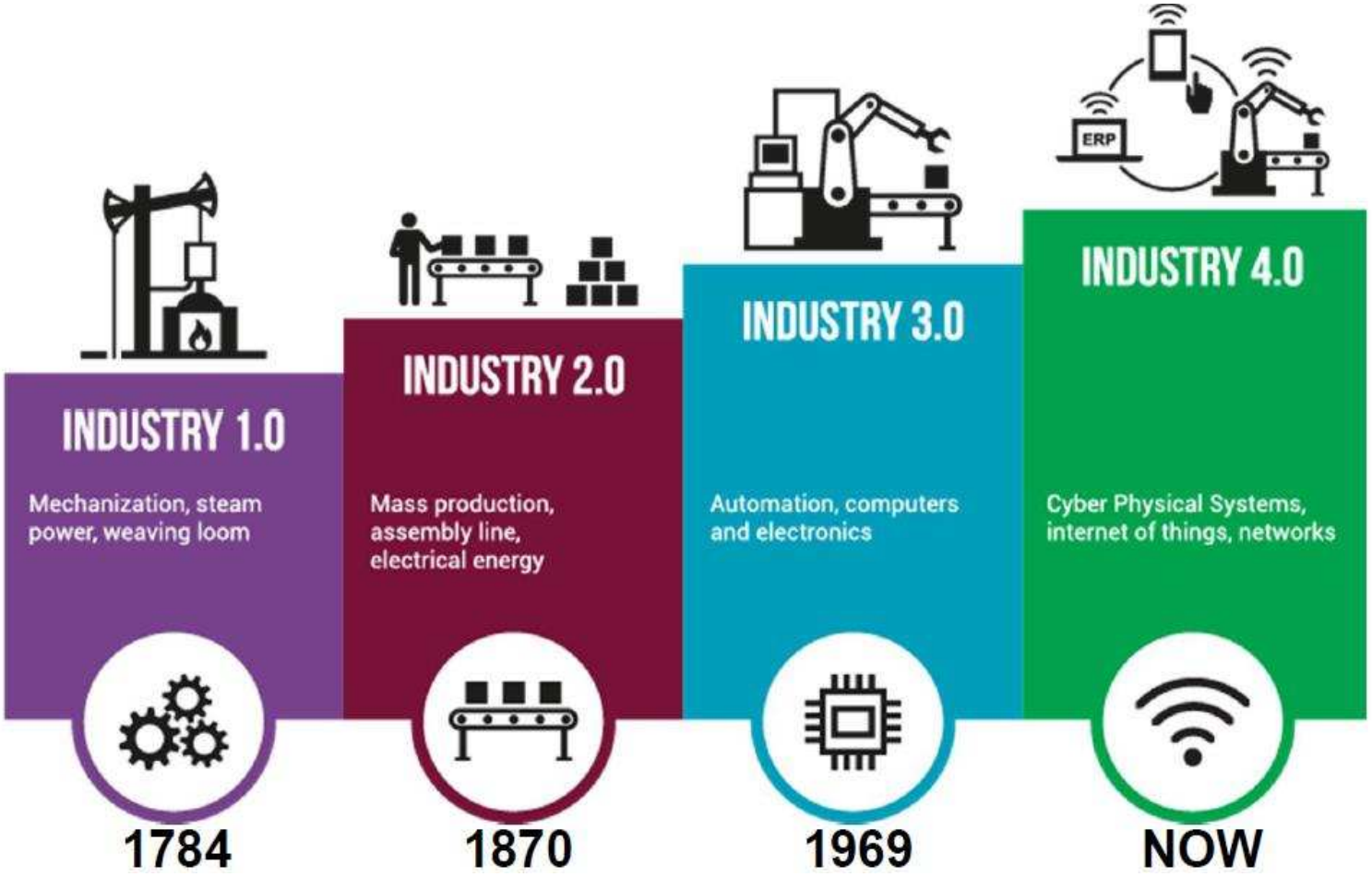
Ideas for Adapting to "New" Economy

- **Portable benefits strategies—ownership—can be taken from job to job**
  - Healthcare and workers' compensation insurance through worker-controlled benefits exchanges
- **Minimum Wage Increase**
  - Raise from $7.25 (2009); index future increases to median wage growth
- **Portable retirement Investment Accounts**
  - Address shift from defined benefit pension plans to tax preferred defined contribution options
  - https://www.warner.senate.gov/public/index.cfm/2020/7/warner-daines-introduce-legislation-to-establish-an-emergency-portable-benefits-fund
- **Restriction of non-compete clauses**
  - Workers making < 3x federal minimum wage, working without a W-2 or in special alternative work arrangements; non-competes apply downward pressure on wages and unnecessarily limit worker mobility
- **Elimination of temporary agency conversion fees**
  - Fee paid to staffing agency from client for converting a temp worker to a FT employee—taken as % temp worker's annual salary
- **Government (BLS) should be tracking of "automatable" and "automated" jobs and tasks**

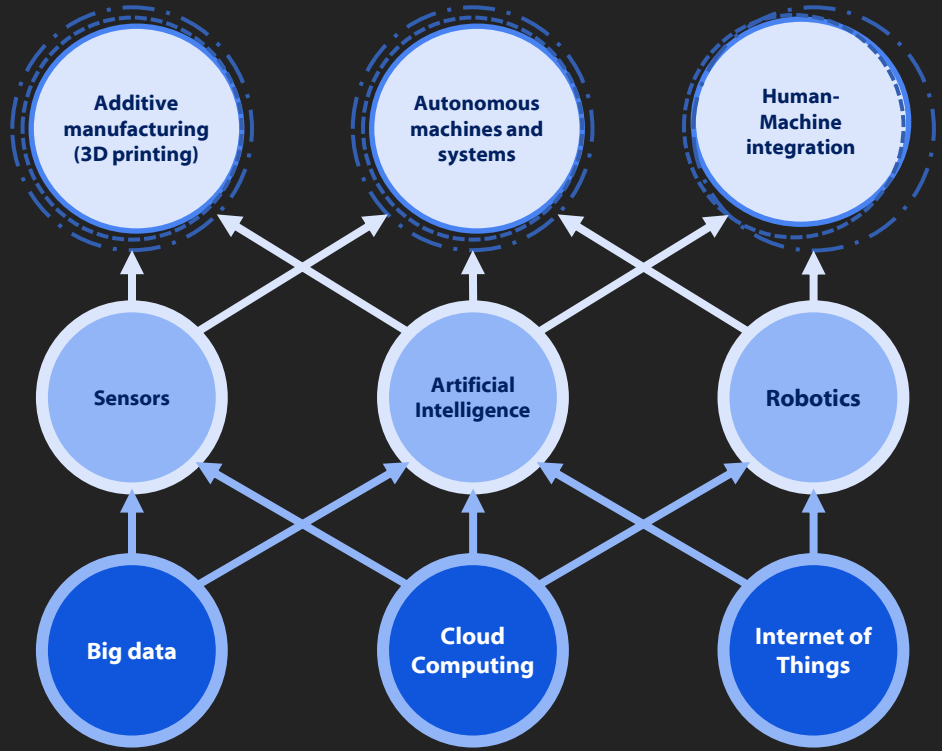
Work

Robotics & Exoskeletons

Artificial Intelligence


INDUSTRY 1.0
Mechanization, steam power, weaving loom
1784
INDUSTRY 2.0
Mass production, assembly line, electrical energy
1870
INDUSTRY 3.0
Automation, computers and electronics
1969
INDUSTRY 4.0
Cyber Physical Systems, internet of things, networks
ERP
NOW

Key Technologies Enabling the Future



Source: OECD (2017)

AIS 2019

Theory of Robotics

- How a robotic device works is as follows:
  - The robot **senses**, the robot **thinks,** and the robot ***acts***…

- How?
  - **Sensing** is done through *interpretation* of data perceived by:
    - Environmental sensors for an embodied robotic device
    - Data inputs from a digital assistant
  - **Thinking** is done through the use of AI methods
  - **Acting** is done through:
    - ***Effectors or actuators by physical*** or **embodied** devices
      - "Steel-collar" workers
    - ***Decision outputs from non-physical*** devices
      - Decision support systems = software ***code***
        - » "White collar" robots or "synthetic" workers

Sensing: Internet of Things (IoT)

- **OMO (online-merge-of-offline)**
  - Combining of our digital and physical worlds such that every object in our surrounding environment will become a data input for the Internet
  - Placeables, wearables, and implantables

- **Sensors are at the heart of the *Industrial Internet***
  - Deploying sensors, entire workplace and everyone in it become *data input* sources.
  - Workplace sensors become intelligent assets operating in physical and virtual space.

- **Sensor improvements can be easily uploaded to the cloud**
  - Immediate and universal sensor connectivity
  - Universal sensor upgradability (not like humans with their meetings)

- **Cloud-based sensor data inputs**
  - Birth of occupational data analytics—new era of surveillance technology?
  - Use of AI to support risk assessment and management decision making
  - Occupational safety and health professionals now are “data decision” scientists

Functional Fabrics—Wearable Sensors

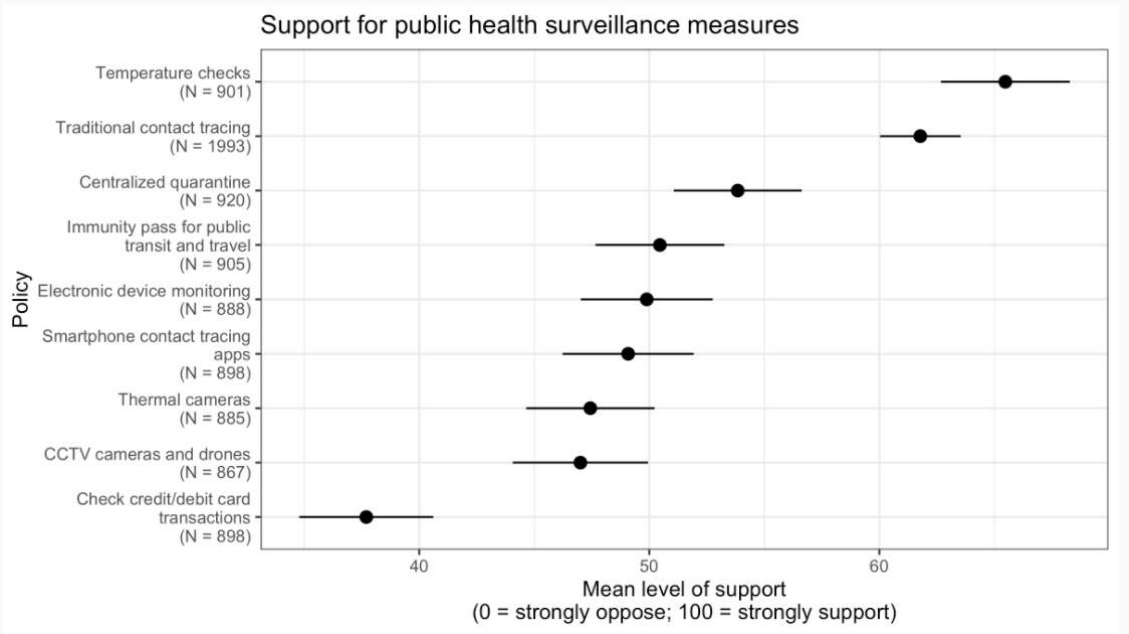
Future of Exposure Assessment?

Marty Ellis, of Inman Mills in South Carolina, checks a machine manufacturing fabric developed through AFFOA.

COVID-19 *Contact Tracing* Wearables

Welcome back to the office—please wear this tracking device!

- Mobile contact-tracing technology has emerged as a measure to track population movements and alert individuals when they come into contact with an infected person.
  - https://www.brookings.edu/techstream/contact-tracing-apps-face-serious-adoption-obstacles/
- Oura
  - "Better understand risk within your population and enable rapid, privacy-first communication to people who show signs of data anomalies that may correlate with illness for a safer, healthier workplace."



Sensor Challenges for OSH Practice

- **Challenges**
  - Precision calibration and validation of sensor instruments
  - Accuracy of sensor measurement outputs as the basis for interpretation
  - Correct hazard characterization?

- **Questions**
  - Given the vast amounts of sensor data that is expected to be generated, how can such data be collected, analyzed, and interpreted by an ***occupational safety and health data decision scientist*** using AI computational methods?
  - How can the occupational safety and health data decision scientist add value to sensor-generated exposure data?

Computer Vision—A Big Sensor Challenge

SAE AUTOMATION LEVELS[1]

0 No Automation
The full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems.

1 Driver Assistance
The *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*.

2 Partial Automation
The *driving mode*-specific execution by one or more driver assistance systems of both steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*.

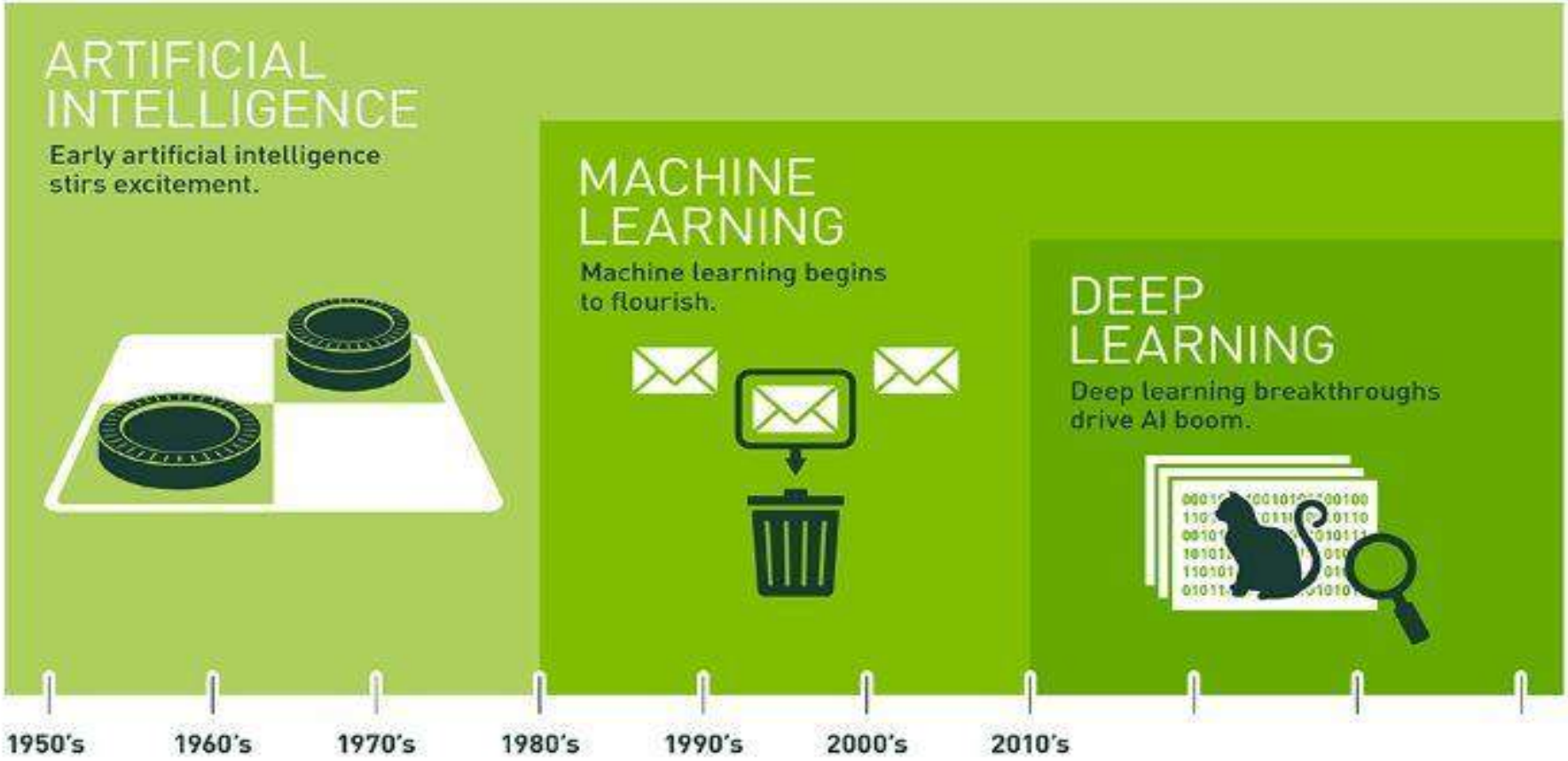
3 Conditional Automation
The *driving mode*-specific performance by an *automated driving system* of all aspects of the *dynamic driving task* with the expectation that the *human driver* will respond appropriately to a *request to intervene*.

4 High Automation
The *driving mode*-specific performance by an *automated driving system* of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene*.

5 Full Automation
The full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*.

1 SAE International, J3016_201806: Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles (Warrendale: SAE International, 15 June 2018), https://www.sae.org/standards/content/j3016_201806/.

Thinking


ARTIFICIAL INTELLIGENCE
Early artificial intelligence stirs excitement.
MACHINE LEARNING
Machine learning begins to flourish.
DEEP LEARNING
Deep learning breakthroughs drive AI boom.
1950's
1960's
1970's
1980's
1990's
2000's
2010's

Artificial Intelligence

- **Machine Learning**
  - Machine is “trained” using large amounts of data (***big data***) and algorithms that give it ability to learn how to perform the task more and more accurately
  - Machine-learning technology powers many aspects of modern society:
    - From web searches to content filtering on social networks to recommendations on e-commerce websites; spoken language and computer vision
    - Increasingly present in consumer products such as cameras and smartphones.

- **Current AI has grown exponentially due to 3 things:**
  - **Explosion in computing power**
    - Graphical processing units operating in parallel
  - **Increase in storage capacity capabilities**
    - Cloud computing
  - **Data accumulation (‘big data’)**
    - Made possible by the Internet

AI and Future of OSH

- Is the data collected by sensors in a state that you can use it rapidly?
  - Do you have the AI applications that you can use to derive value from the data?
  - Are we training data decision scientists with the right skills?

- Are occupational safety and health practitioners trained to make sound risk control decisions using AI?

- Can you “build” a digital twin of a work process, a workplace condition, together with the scope of worker actions within that process, in order to test hazard identification & risk control decision making?

  - Russell & Novig, Artificial Intelligence: A Modern Approach, 4th ed. (2020)
  - Daniel Hulme, https://www.strategy-business.com/article/Understanding-the-Potential-of-Artificial-Intelligence

Acting: Robot Advantages

- **Better than human workers at routine, precise or repetitive tasks**
- **Better at finding patterns in thousands of dimensions**
- **Better going into hazardous environments**
- **Better at managerial tasks**
  - Remind a team of deadlines, procedures, and progress
    - Keep perfect record of project progress
    - Provide real-time scheduling and decision support
    - Demonstrate perfect recall
- **Lower Operational Costs**
  - Costs average $8 an hour to use a robot for spot welding in the auto industry, compared to $25 for a worker—and the cost savings quotient is only going to widen.

Commercial Types of Robotics

- **Assembly line robots**
  - Fixed in location
  - Humans and robots are separated from each other
- **Collaborative robots**
  - Designed to work together with humans
- **Service robots**
  - Autonomous ground vehicles
  - Unmanned aerial vehicles
  - Household service robots
- **Social Robots**
  - Detect and express human emotion
  - Act as companions
- **Wearable Robotics**
  - Exoskeletons

Robots Becoming More Capable

- Object detection
- Grasp dexterity
- Placement verification

Robotics: Safety and Health Risks

Potential

- Can transfer hazardous work from human workers to robotic workers
- Can augment human workers' abilities
  - Team of human workers and robot workers are more productive

Concerns

- Likely increase in robot-related human worker physical contact injuries

- New types of robots will require refined and new protection strategies
  - Robot with **dynamic machine learning** capabilities can challenge **static safety procedures**

- Rapid advances in robot and sensor technology will outpace national standards setting
  - Impetus for international consensus standard-setting

- Bias in digital assistants and lack of transparency in decision making

- Worker stress
  - Changing workplace
  - Job displacement

ANSI/RIA Robotic Safety Standards

- **ANSI/RIA R15.06-2012**
  - American National Standard for Industrial Robots and Robot Systems—Safety Requirements (revision of ANSI R15.06-1999)
    - Approved March 28, 2013
    - Revision underway
  - Provides guidelines for the manufacture and integration of industrial robots and robot systems
    - Emphasis on their safe use, the importance of risk assessment and establishing personnel safety.
    - Key feature in the standard is “collaborative operation”
      - Introduction of a worker to the loop of active interaction during automatic robot operation.

Industrial Exoskeletons

Exoskeleton devices are being introduced across several industry sectors to augment, amplify, or reinforce the performance of a worker's existing body components—primarily lower back and upper extremities.

- May play a role in reducing work-related MSDs arising from lifting and handling heavy materials or from supporting heavy tools in overhead work. However, wearing an exoskeleton may pose a number of risks that are currently not well-studied.

- There are only a few peer-reviewed, published studies about the safety and health implications of wearable exoskeletons and most of those studies involve only a small number of participants.

- There is need for prospective interventional studies to evaluate the safety effectiveness across industry sectors.

  – Howard et al. Need for interventional effectiveness research. *AJIM* (2019)

Intelligent Digital Assistants

White Collar Robots

Sensors → Data Inputs

Thinking → Artificial Intelligence

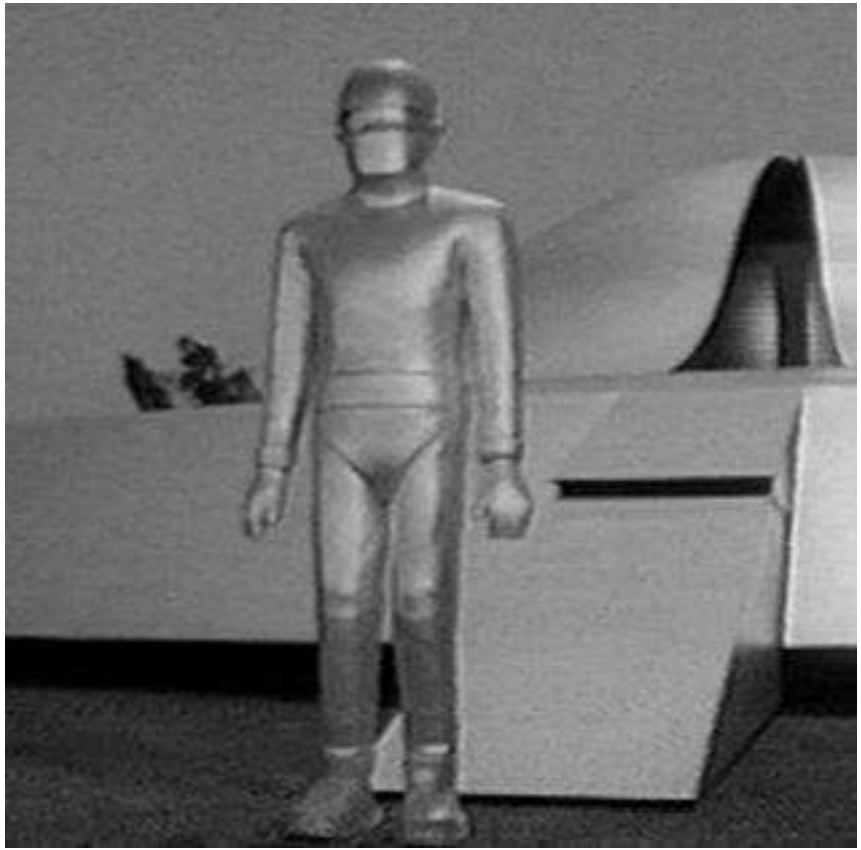
Acting → Decision Support Systems

White Collar Robots

- Amelia
  - Works at Swedish Bank SEB and in Zurich for UBS
  - Speaks 20 languages (at same time)
  - Handles thousands of call simultaneous and can memorize a 300-page manual in 30 seconds
- Advantages
  - Cheaper than a human worker times many, many
  - Leaves digital trail that makes reporting for regulatory compliance faster and higher quality
- Other WCRs
  - **Erica—Bank of America**
  - **Watsons—IBM**
  - **Einstein—Salesforce**
  - **Nia—Infosys**
  - **Cortana—Microsoft**
  - **Alexa—Amazon**
  - **Siri—Apple**

AI-Enhanced Safety Management

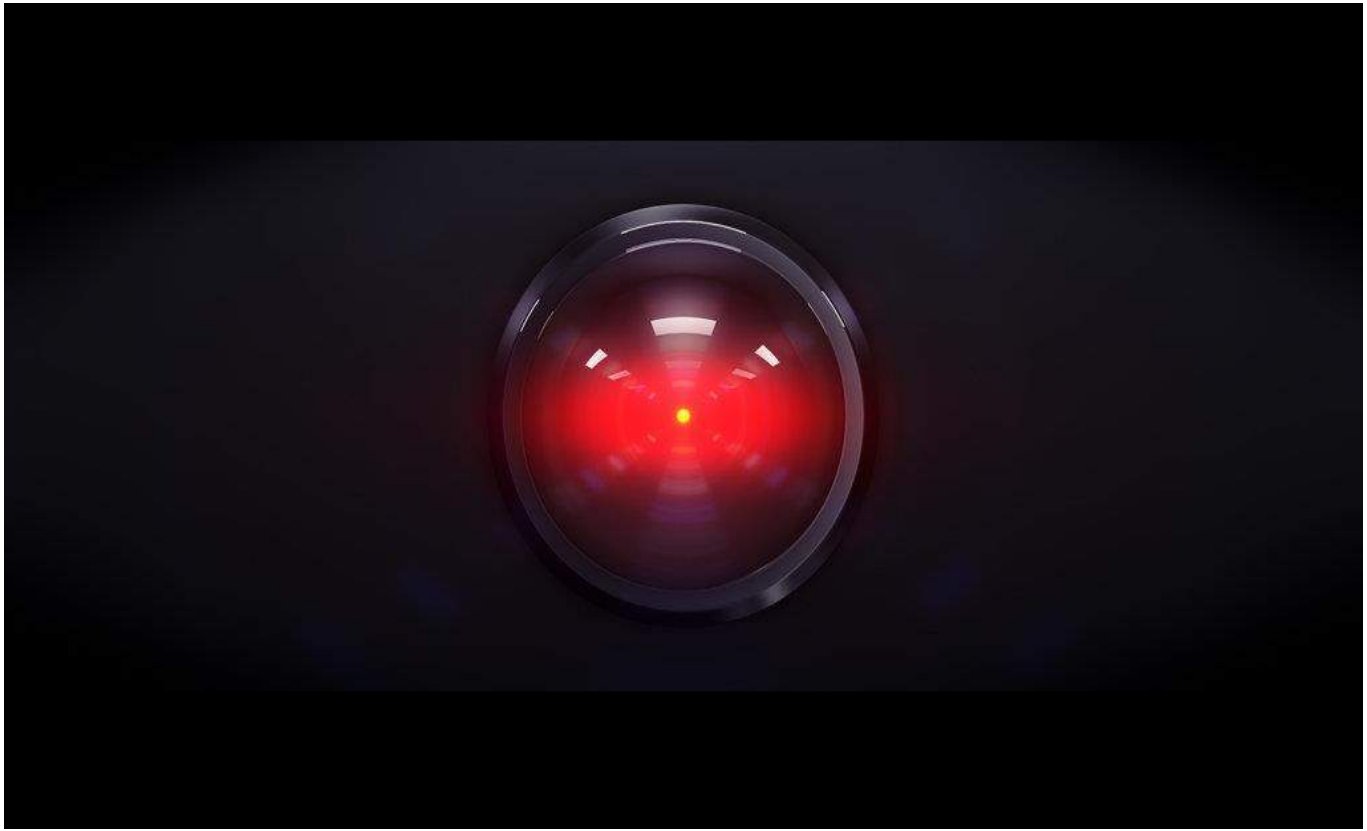
- Can AI be used to assist humans in recognizing a near-miss?
- Can AI be used to assist humans to offer more accurate risk mitigation recommendations than humans can alone?
- Can AI take control to prevent human actions that may create safety and health hazards?



Consensus Standards Setting

- ANSI/RIA R15.06 – Industrial **Robots and Robot Systems Safety** (*Update)*
- ANSI/RIA R15.08 – Industrial **Mobile Robot Safety** *(New)*
- ASTM F48 – **Exoskeletons and Exosuits** *(New)*
  - Committee addressing safety considerations in designing and selecting exoskeletons; system training; load handling when using an exoskeleton; recording environmental conditions for utilization with exoskeleton test methods; labeling and information for exoskeletons and exosuits; and wear, care, and maintenance instructions.
- ANSI/ASSP/NSC Z15.3- Safety Management of **Partially and Fully Automated Vehicles** *(Technical report)*
- ANSI. **Unmanned Aircraft Systems Standardization Collaborative** (UASSC). Released version 1.0 of its standardization roadmap in December 2018, and version 2.0 in June 2020. Identifies existing standards and standards in development, defines where gaps exist, and makes recommendations for priority areas where there is a perceived need for additional standardization including pre-standardization research and development (R&D).

"I'm sorry Dave, I'm afraid I can't do that"



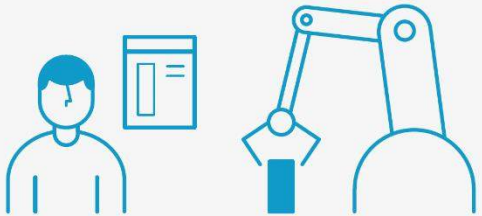
Workforce

Skills Gap

Automation

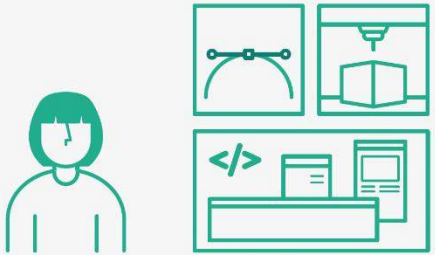
THREE SHIFTS ARE UNDERWAY

1. UNBUNDLING OF WORK FROM JOBS



Jobs are no longer the organizing unit for work; rather, there is a redistribution of tasks between humans and machines, depending on who is best suited to do the job

2. NEW WORK, NEW SKILLS

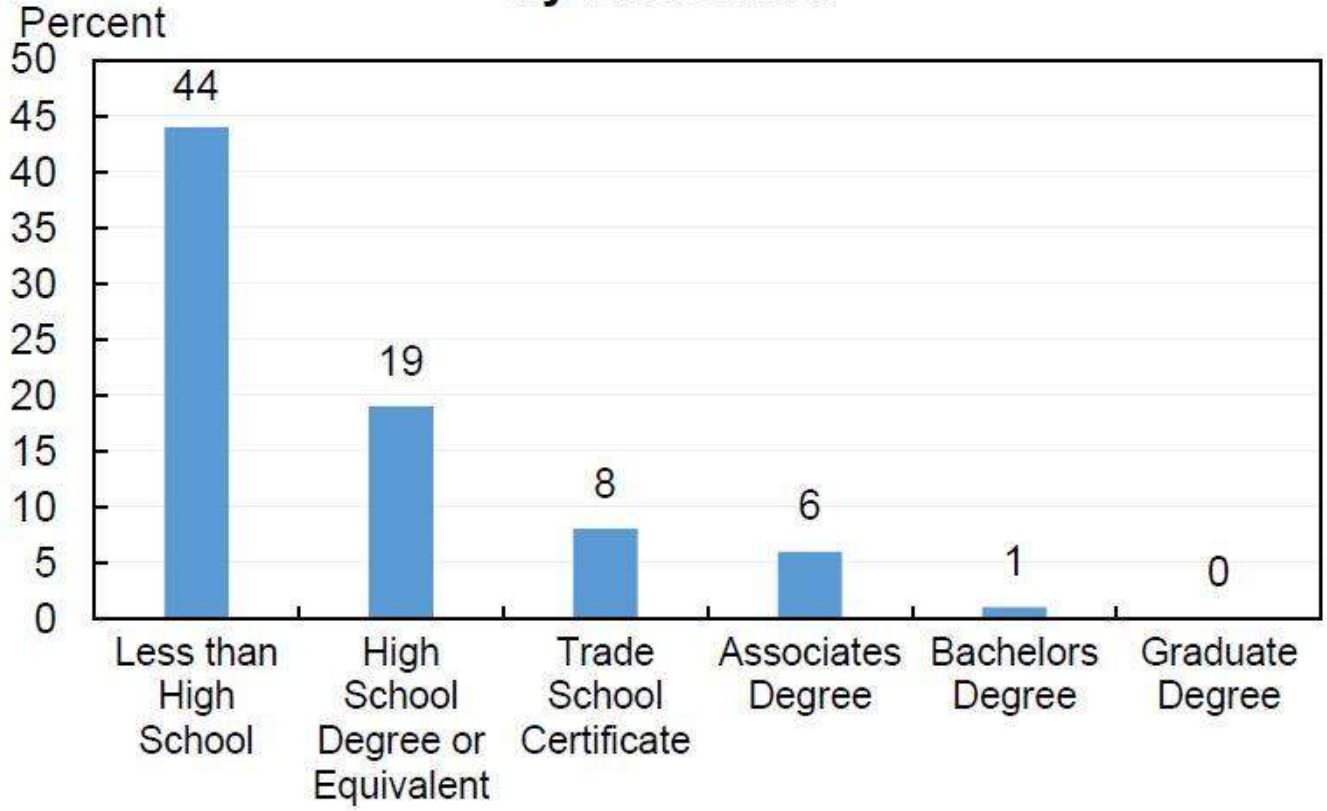


With the rise of new technologies, we will see the emergence of new roles associated with the design, development and maintenance of new technologies

3. HIGHER COGNITIVE COMPLEXITY OF HUMAN WORK

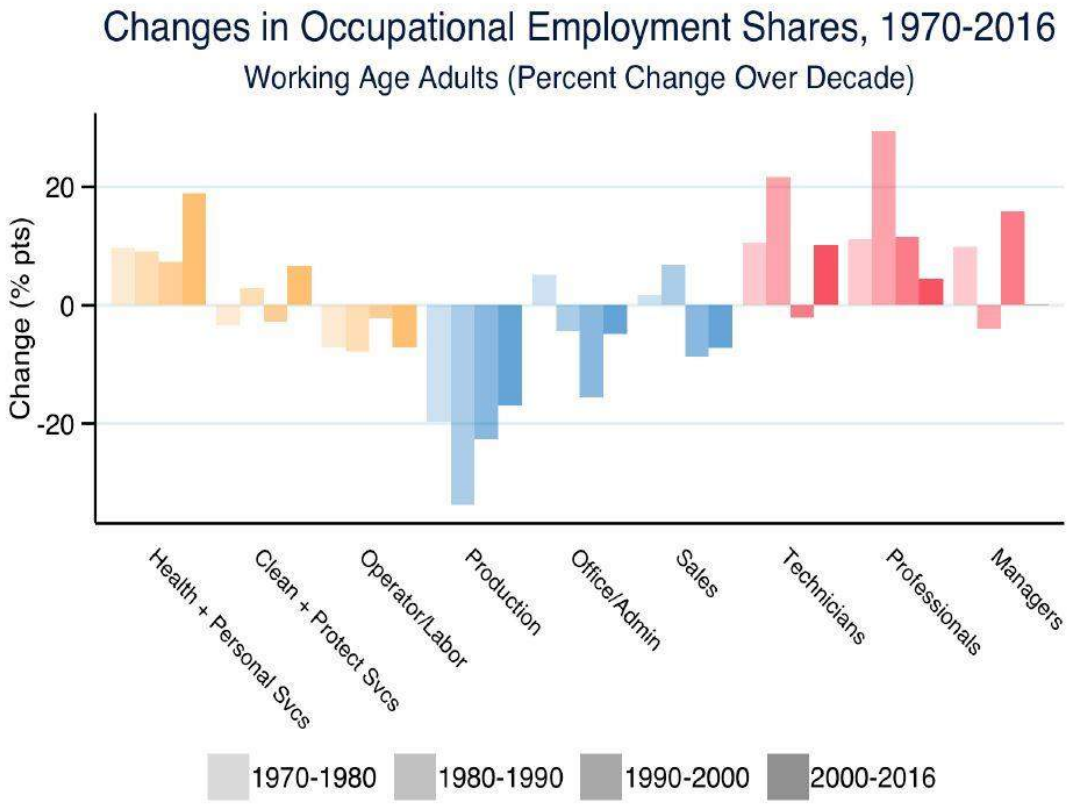
The human workforce of the future will execute tasks requiring higher cognitive and emotive complexity, and activities requiring the application of general intelligence

Share of Jobs with Highly Automatable Skills, by Education



Source: Arntz, Gregory, and Zierahn (2016) calculations based on the Survey of Adult Skills (PIAAC) 2012.

Occupational Polarization by Job Skills



Key Observation — Polarization of Work

High skill jobs

- **Rising** employment in professional, technical and managerial work

Low skill jobs

- **Rising** employment in personal services — Cleaning, security, recreation, health aides

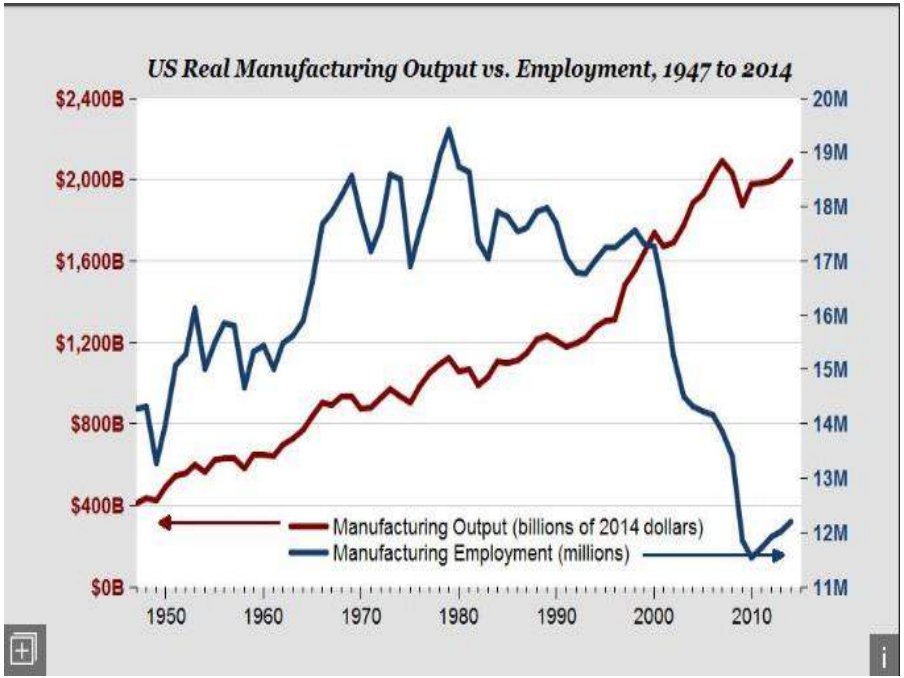
Mid skill jobs

- **Falling** employment in production work, office/clerical, and sales

Technological Job Displacement

Job Density

- In manufacturing, job density—the number of jobs per process—is declining.
- In 1980 it took 25 jobs to generate $1 million in manufacturing output in the U.S.
- Today it takes five jobs.
- Why?

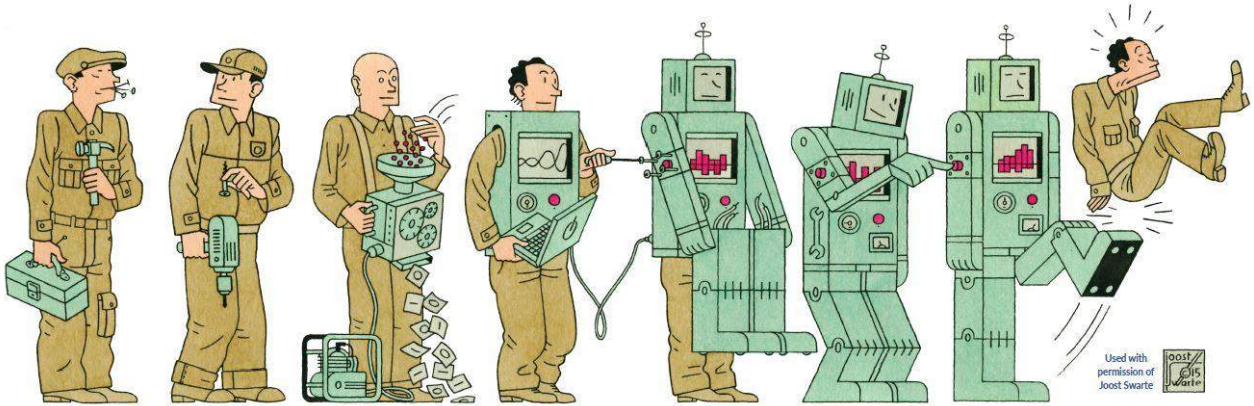


It’s Trade with China

- **Trade (China)**
  - Between 1990 and 2011 the share of global manufacturing exports originating in China surged from 2% to 16% (Hanson, 2012).
  - Intensifying import competition from China means a reduction in demand for goods U.S. manufacturers produce and a corresponding contraction in the number of workers they employ.
    - Autor, Dorn & Hanson (2013). The China Syndrome: Local Labor Market Effects of Import Competition in the United States. *American Economic Review,* 103(6): 2121–2168.

It’s Technology

- **Technology (Robotic Automation)**
  - Brynjolfsson, *Race Against the Machine and Second Machine Age*
  - If the trend toward the automation of routine jobs in advanced manufacturing continues, the application of new technologies is likely to do much **more** to boost growth in value added than to **expand** employment on the factory floor.
    - Autor & Dorn (2013). The Growth of Low Skill Service Jobs and the Polarization of the US Labor Market. *American Economic Review*, 103(5):1553-1597.

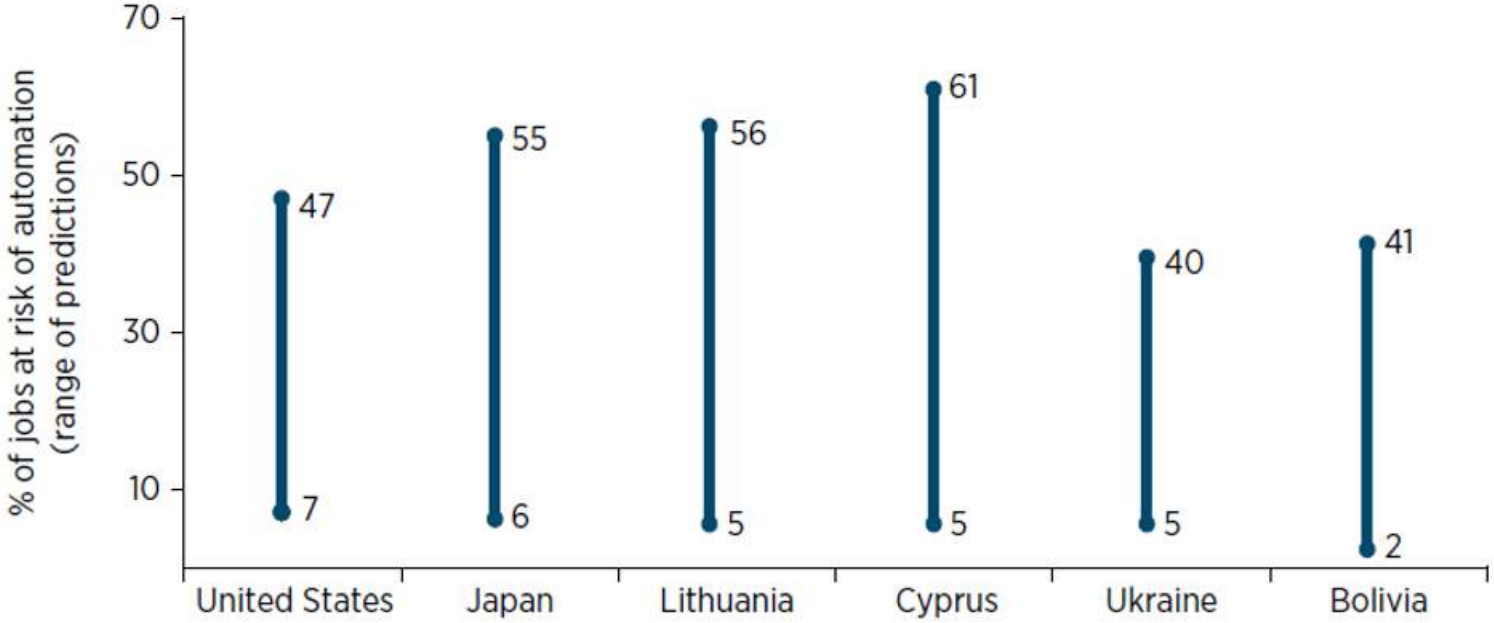


Technological Unemployment

Estimates are Between "Big and Enormous"

Organization	Estimates
University of Oxford	47% of workers in America at high risk of jobs replaced by automation
PricewaterhouseCoopers	38% of jobs in America, 30% of jobs in UK, 21% in Japan and 35% in Germany at risk to automation
ILO	ASEAN-5: 56% of jobs at risk to automation in next 20 years
McKinsey	60% of all occupations have at least 30% technically automatable activities
OECD	OECD average: 9% of jobs at high risk. Low risk of complete automation but an important share (between 50% - 70%) of automatable tasks at risk
Roland Berger	Western Europe: 8.3m jobs lost in industry against 10m new jobs created in services by 2035.
World Bank	2/3 of all jobs in developing countries are susceptible to automation.
Bruegel	EU countries: between 47% and 54% of jobs are risk of automation

Source: Frey and Osborne (2015); Roland Berger (2016); McKinsey Global Institute (2016); PwC (2017); World Bank (2016); Chang and Huynh (2016); Bowles (2014) and Bruegel Blog (2014)

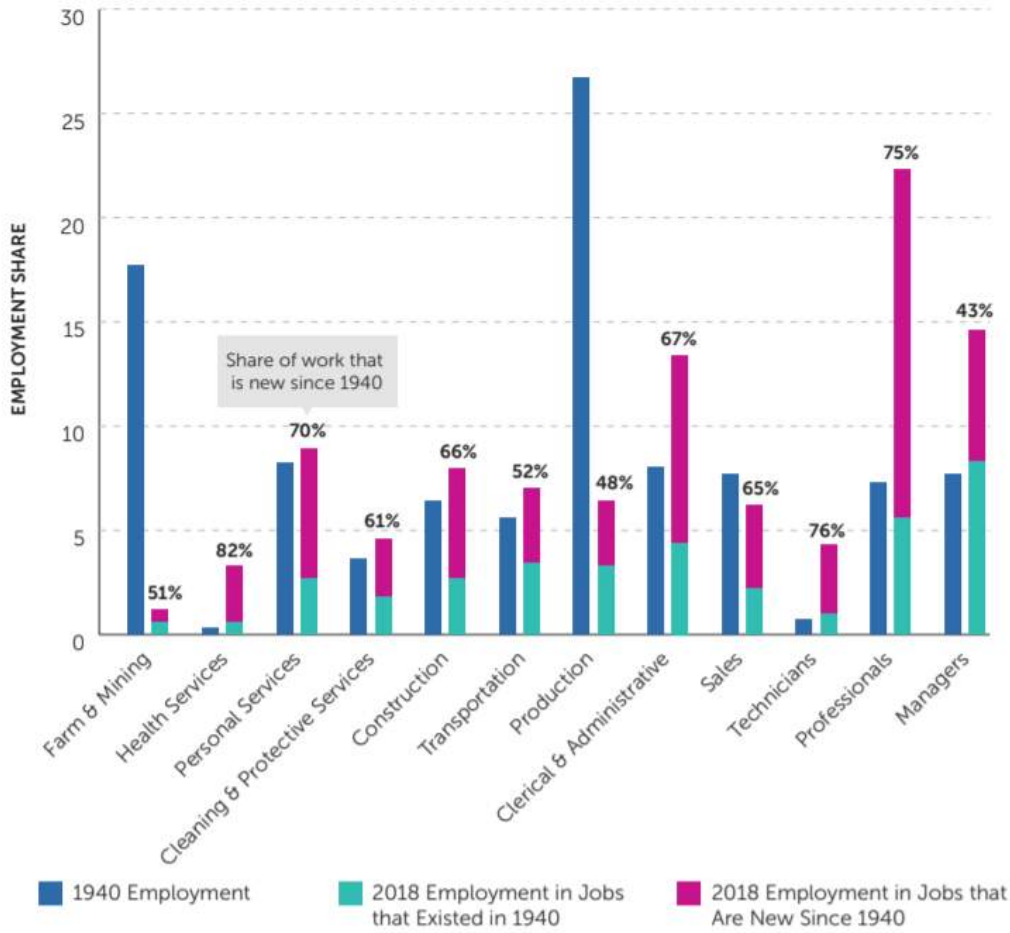


Sources: WDR 2019 team, based on World Bank (2016); Arntz, Gregory, and Zierahn (2016); David (2017); Hallward-Driemeier and Nayyar (2018).

Note: The figures represent the highest and lowest estimates of the percentage of jobs at risk of automation in economies for which more than one estimate has been produced by different studies. A job is at risk if its probability of being automated is greater than 0.7.

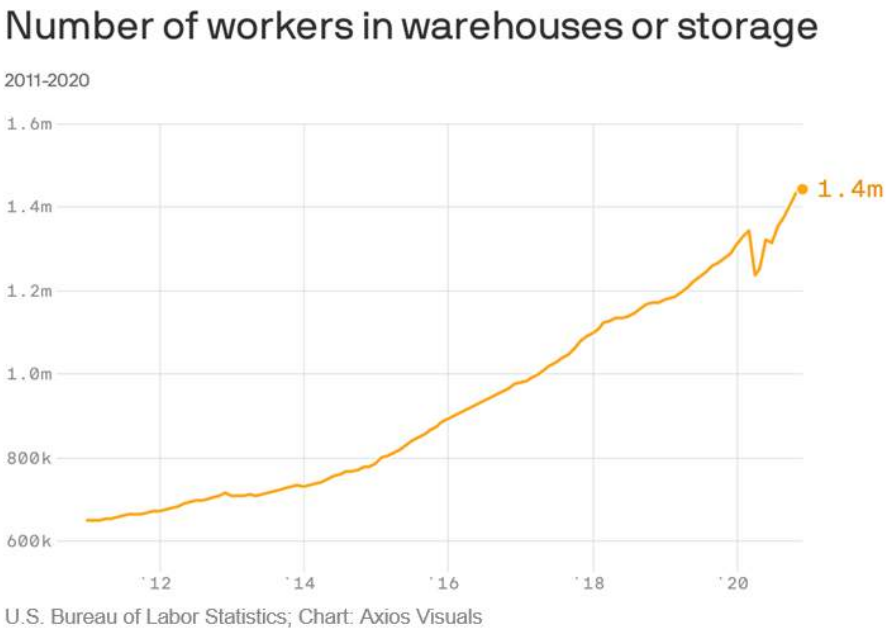
Job Creation and Job Destruction

- More than 60% of jobs done in 2018 had not yet been "invented" in 1940
- Even as automation eliminates human labor from certain tasks, technological change leads to new kinds of work.
- MIT Future of Work (2020)



E-Commerce and the Pandemic

- E-commerce sales rose to more than $211 billion in the second quarter of 2020 as the pandemic shifted consumers online—an all-time high of 16.1% of total retail.
- E-commerce sales were up more than 5,000% from when tracking began at the end of 1999.
- Employment in warehouses and storage — the backbone of the e-commerce industry — rose to more than 1.4 million workers by last month, more than double the total from a decade ago.
- With more Americans employed in the warehouse sector, the quality of those jobs — and the effect automation will have on them — will be increasingly important.

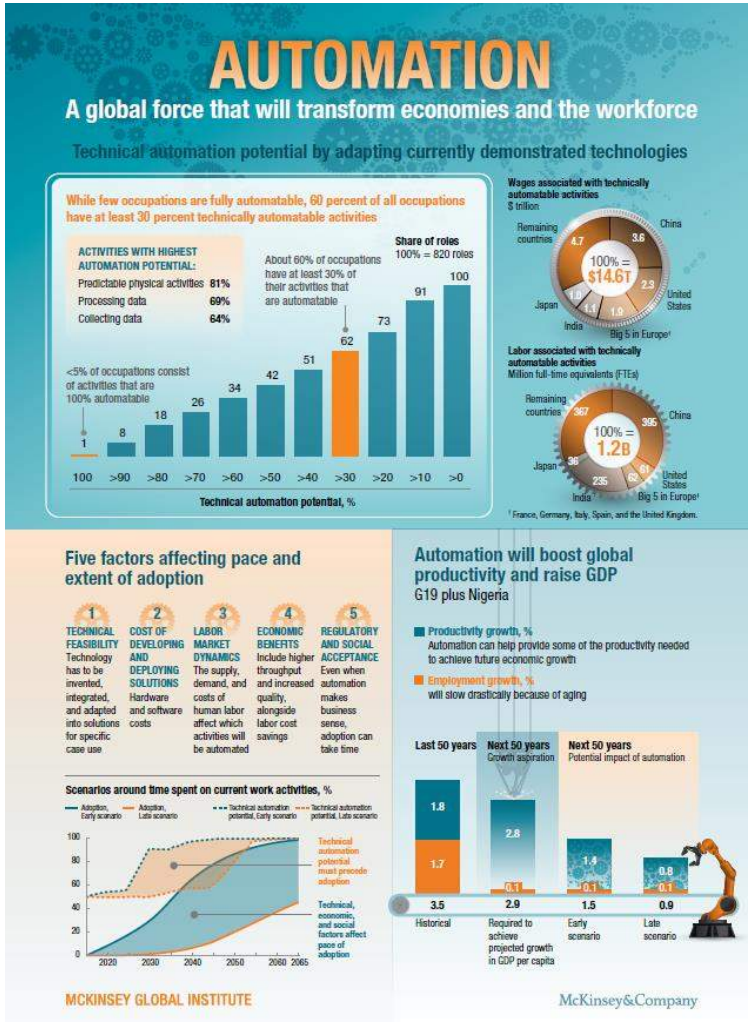


Technology and Jobs

- Talk of automatic machines replacing humans goes back to the ancient world. Aristotle in 350 BCE:
  - “For if every instrument could accomplish its own work…chief workmen would not want servants, nor masters slaves.”

- Machines, Robots and Technological Unemployment
  - Luddites—1811
  - Depression—1873-1879
  - Depression—1890
  - Great Depression—1930
  - Great Recession—2008

- “No compelling historical or contemporary evidence suggests that technological advances are driving us toward a jobless future.”
  - MIT The Work of Work (2020)



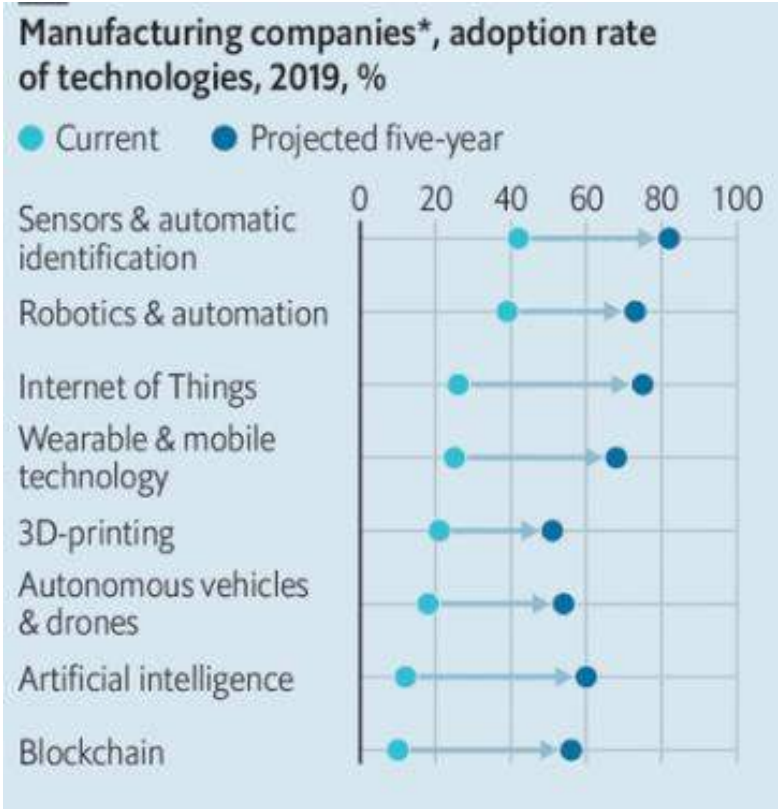
Substitute or Complement?

- In the workplace, robotic device can perform:
  - A job that a human worker once did
    - The robot acts as a ***substitute*** for a human worker.
  - The robotic device can assist a human worker to perform a job
    - The robot acts as a ***complement*** to a human worker.

Adoption Rate for Emerging Technologies

https://www.economist.com/business/2021/01/16/after-years-of-dithering-companies-are-embracing-automation

- Firms have boasted of automating their operations for years without an awful lot to show for it. Covid-19 has spurred them to put their money where their mouths are.
- Estimates are that between now and 2030 American firms will invest $10trn in automation
- Sensors & robots are the most prominent winner.
  - By the end of 2021 the worldwide installed base of factory robots will exceed 3.2m units, double the level in 2015. The global market for industrial robotics is forecast to rise from $45bn in 2020 to $73bn in 2025.



Pace of AI-Enabled Automation

- **Adoption Determinants:**
  - Technical feasibility
  - Cost of deployment
  - Labor market dynamics
  - Economic benefits
  - Regulatory/social acceptance

- **Reconciling potential with reality**
  - Beane M & Brynjolfsson E. Working with robots in a post-pandemic world. MIT Sloan Management Review, Winter 2021. https://sloanreview.mit.edu/article/working-with-robots-in-a-post-pandemic-world/

- **Some Things Could Be Automated but…**
  - # School Bus Drivers 2020
  - # School Bus Drivers 2030?

Thank You!