Will a Robot Take Your Job?

June Zaccone, April 2017

[Slide1] We may be at the beginning of a new industrial revolution. Computers could lead us to effortless production matched with social disaster for jobless workers without income. The rapid advances have surprised even Google's Sergey Brin.[1] Though a transition is underway, computerization has not yet led to mass joblessness and can't be blamed for our current wage stagnation or inequality.[2]

How likely is a robot-dominated world? [The term "robots" can include both devices that make cars or unload ships and those that choose stocks for hedge funds.[3]] With the breakthroughs that gave us Google Translate and beat the Korean Go master, "Machines have crossed a threshold. They've transcended what humans can do."[4] The potential for social upheaval this creates has as little place on our political agenda as climate change. This threat to jobs was the subject of last year's World Economic Forum. Its chairman concluded,

> "Without urgent ...action today to manage the near-term transition and build a workforce with futureproof skills, governments will have to cope with ever-growing unemployment and inequality, and businesses with a shrinking consumer base."[5]

[Slide2] The question may become more pressing. The global supply of industrial robots is rising, with a boom in Asia. Japan has lost its first place in robot use to China. Though the US ranked 7th in innovation in computer technologies in 2015, it lags in using them: it was 9th in business use, 12th for consumers, and 13th in government use, according to a ranking by McKinsey, the consulting firm.[6] The journal *Foreign Affairs* devoted an issue to the subject,[7] and continues to follow it. One author, Daniela Rus, who directs MIT's Computer Science and Artificial Intelligence Lab, has an optimistic take:

> "... the objective of robotics is not to replace humans…; it is to find ways for machines to assist ...humans.... Robots are better than humans at crunching numbers, lifting heavy objects, and, in certain contexts, moving with precision. Humans are better than robots at abstraction, generalization, and creative thinking, thanks to their ability to reason, draw from prior experience, and imagine. By working together, robots and humans can augment and complement each other's skills."[8]

Her colleagues, Eric Brynjolfsson and Andrew McAfee,[9] expect technological change to speed up,[10] but predict that people will remain an important part of the economy. Computers can now perform tasks formerly deemed impossible, like translating foreign languages or driving cars. "Machines, it seems, can do almost anything human beings can. …. We are at the dawn of the second machine age,"[11] they say. These technologies will leave many behind.[12] Workers will face online global competition while computerization destroys jobs.[13] Though human labor is likely to become far less necessary overall, they believe, people can choose to avoid becoming economically irrelevant. However, no one expects an effortless transition.

China, despite its abundant labor, now leads the world in robot patent applications.[14] Their effort stems from the mismatch between factories looking for skilled labor and college graduates who don't want these jobs. Chinese and foreign factory owners have a reputation as killing and stingy bosses.[15] Foxconn, producer of iphones, where some workers committed suicide by jumping out of factory windows, is installing 30 thousand robots a year to do routine work like welding and assembly. Their long-term plan is to replace most workers.[16] In the meantime, they've installed suicide prevention nets rather than improve work conditions. Other

incentives are government subsidies,[17] rising wages and a shrinking workforce.[18] [Slide3] Automation is spreading from heavy industry, like Mercedes-Benz auto manufacturing, to those like consumer electronics and clothing requiring greater precision.[19] [Slide4] A major incentive is production efficiencies, achieved by this cell phone factory. Production more than doubled and defects declined despite firing 90% of workers. China's goal is a robot-to-worker ratio of 1 to 100 by 2020, nearly three times its current ratio. The current U.S. ratio is already higher: 1.6 robots for each 100 workers; Japan's, 3.2, and South Korea's a much higher 4.8.[20]

With rising robot utility and falling prices, some predict that even the world's lowest-paid workers won't be able to compete. Intelligent machines are already diminishing the value of work. In fact, the poorest countries have the highest share of replaceable jobs.[21] Many pundits recommend that workers get better training, [22] and this is important, but with rapid change, improving education will always be "too little, too late." [23] Computer innovation has the potential for far more disruption than previous technologies: transfer speed is now far greater, and effects are global.

This paper aims to evaluate the threat. What jobs have been replaced or are replaceable, and what can't be automated? What issues are raised by computer-assisted decision-making? Why aren't there major job losses? If much of the work force is jobless, who will consume the output? We'd be back to the dilemma, now global, posed by United Auto Workers president, Walter Reuther, touring a Ford Motor plant in 1954:[24]

> A company official proudly pointed to some new automatically controlled machines and asked Reuther: "How are you going to collect union dues from these guys?"
>
> Reuther replied: "How are you going to get them to buy Fords?"

There is little evidence yet of a machine takeover. [Slide5] Productivity growth, which measures how fast output per worker is rising, has slowed. Productivity is encouraged by economic growth,[25] like the postwar boom in late 1940's. If technology is rapidly displacing workers, it should show up here. An Obama White House report, noting the slowdown in most industrial countries, concludes it has not yet had a major effect.[26] Labor problems of weak wages and unemployment so far reflect primarily weak demand and weak unions, not technological displacement.

Societies with disruptive change must try to protect people. Change is inevitable, but its speed and whether its effects are mitigated determine the misery of those who lose.[27] The new technologies presage disruption, as students and workers won't know what to specialize in to remain relevant, and will have to "reinvent themselves over and over and faster and faster."[28] Paradoxically, automation may lead to reshoring in more developed economies as costs fall.[29]

The fear that most jobs would be eliminated by machines has a long history. [Slide6] The most famous reaction was during the Industrial Revolution, when English textile workers known as Luddites, destroyed machines, trying to protect their jobs from mechanical power. Even if job losses in the short term are more than offset by job creation in the long term, the experience of 19th century Britain shows that the transition is likely to be traumatic. Eventually, economic growth took off after centuries of stagnant living standards, but decades

passed before wages and conditions improved. The rapid shift of growing populations from farms to urban factories contributed to unrest across Europe. Governments took a century to respond with new education and welfare systems. This time the transition is likely to be faster.[30]

In our own day, there was a panic about "technological unemployment" in the 1960s, when robots [31] first appeared, and in the 1980s when computers began replacing secretaries. Each time, automation threatened jobs. Each time, technology created more jobs than it destroyed. ATMs replaced bank tellers, but made new branches cheaper. Their spread created more jobs in sales and customer service. Only now is the number of bank tellers declining.[32] E-commerce increased overall retail employment, though it has destroyed some businesses, like bookstores. Some analysts believe the effects of computers will be similar;[33] others predict disaster for most workers.[34] A chronic problem is that jobs created are mostly for people other than the ones who lost them, sometimes elsewhere in the world. The secretary may have to take a job at McDonalds.

How rapidly will the transition take place? Estimates vary widely.[35] According to a much-cited Oxford study,[36] up to 47% of American jobs are at high risk in the next decade or two. Though low-wage workers are predicted to be most at risk, McKinsey[37] found a weak correlation between automatability and wages. For example, some one-fifth of the tasks of chief executives—like data analysis or "reviewing status reports"—are more susceptible than those of landscapers. Even now they could be done by a robot. But not managing others—so no robot bosses yet.[38] McKinsey and others project that technology will replace tasks rather than entire occupations, like tax software changing the work of accountants. This will affect an estimated 60% of jobs, but only 5 percent will be completely lost.[39] Others conclude that nearly all jobs can at least partially be replaced.[40]

Some industries have already been transformed. The Blockbuster video chain disappeared completely, with new ways of delivering their product. Music sales have been decimated, especially formats that take a physical form, like cds. Digital dollar sales have fallen as well. In other industries, production will continue with reduced employment.

Unlike early automation, which replaced relatively unskilled labor, skilled professions are now affected as well—loan officers, lawyers, and journalists. IBM is recasting its Jeopardy-winning technology "to diagnose diseases and read medical images." A recent *New Yorker* article was titled, "The Algorithm Will See You Now." Expert systems are increasingly used to assess engineering designs. When jobs were destroyed in agriculture, others were created in factories; later, factory automation was offset by service jobs. Today there is no such obvious replacement sector, though we have a poor record in predicting new industries.[41]

Let's look at what computers already do.

- In 2013, the FDA approved a machine that delivers sedation to patients without an anesthesiologist. Radiologists are competing with computer-aided diagnosis, as well as programs that can far better identify problems with knee implants.[42]

- [Slide7] A robot surgeon has been taught to perform a delicate procedure—stitching soft tissue together with a needle and thread. It uses a "3-D imaging system and very precise force sensing to apply stitches." It outperformed its teachers.[43]
- Computer programs now write readable copy faster than most writers. Using them, Associated Press publishes quarterly earnings reports for 4,000 companies, up from 400.[44] [Slide8] However, though these reports provide the facts, they lack the human interest of the sports writer [in blue].
- Researchers are testing tiny robots that travel in the body, communicate with each other, perform tasks like diagnosis or drug delivery, and degrade when they are finished.[45]
- [Slide9] Robots have helped to provide physical therapy for decades. A robot guides limb movements of recovering stroke victims. A Yale researcher says. "Anytime you could use a good personal coach or trainer, we're starting to see robots involved…."[46]
- [Slide10] Japan has built a hotel mostly staffed by robots.[47]
- [Slide11] there are driverless cars and robot delivery... Singapore already has driverless taxi services.[48] Self-driving cars threaten the livelihood of 3½ million truck drivers.[49] Uber is testing autonomous trucks, so far with a driver as monitor, and cars are already being tested on roads in several states. They seem to be clearly in our future, predictions which range from a few years to a few decades.[50]
- [Slide12] Robots make good ranchers.
- [Slide13] a Dutch team including art historians[51] used computer programs and 3-D-printing to produce a portrait that looks like a previously unknown Rembrandt.
- [Slide14] A Stanford University student has created "the world's first robot lawyer." DoNotPay[52] helps users contest parking tickets. Its questions help it decide whether an appeal is possible ["were there clearly visible parking signs?"], then guides users through an appeal. It's free, and in its first 21 months, accepted 250 thousand appeals, winning 160 thousand.[53] It's now helping refugees file immigration applications.[54]
- An online divorce negotiator can replace divorce lawyers: it "find[s] points of agreement, then propose[s] solutions." A tool can calculate child support, and software generates agreements.[55]
- The Catholic Church approved an app for confession, available on itunes. It permitted sinners to track sins, and provided them with a user guide and seven choices for contrition. Some Catholics decided that they could abandon confession to a priest completely until the Vatican ruled against it.[56]
- [Slide15] And of course, robots easily check inventory, or move it.
- In 2000, there were over 5500 floor traders on the New York Stock Exchange; now there are fewer than 400, many working part-time. Trading algorithms are making decisions.[57] Goldman Sachs has replaced 600 traders executing orders of large clients with two, supported by automated trading

programs and 200 computer engineers.[58] Of course this provides more profits at the top. Entry-level jobs are likely to be hit hard; "if you can teach a recent college grad to do [it], you can probably teach a machine...."[59] A JPMorgan Chase program reviews commercial loan agreements in seconds that once kept lawyers and loan officers busy for thousands of hours. And with fewer errors.[60]

- Chatbots, robots simulating human speech, are coaching call-center workers. As these talk to someone, the software might recommend talking more slowly or warn that the customer seems upset. [Slide16] They can also be used for customer service themselves.

One of the robots that seemed threatening to jobs is Baxter, which costs just $24,000 and doesn't require changing factory settings to perform new tasks.[61] Someone with no robotics experience simply moves Baxter's arms around and follows prompts on the robot's face.[62] However, it has not been very successful, especially with manufactures requiring highly accurate motions. Human movements can't teach this.[63] The current version, Sawyer, is more promising. Computer programs can quickly plow through massive data sets, like loan applications, résumés, or teacher evaluations, and choose the top candidates. Its costs, like computer processing, bandwidth, and storage are falling rapidly.[64] Robots don't need to be perfect to steal our jobs — "they only need to be better" than we are.[65]

Artificial Intelligence [AI] is a major force driving new technology. It has created the progress in speech recognition, like Apple's Siri; machine translation; and image recognition that are replacing professionals. Herbert Simon,[66] a Nobelist in economics and all-round genius, and Allen Newell invented the field of AI in the 1950s. [Slide17] AI refers to any program that does something that we'd think of as intelligent if done by a person.[67] Some examples are search engines like Google, speech recognition like dictation programs, and expert systems, programs which embody the knowledge of experts, like giving divorce advice or making high-risk credit decisions.[68] AI is embodied in algorithms. These are rules that guide a computer in problem-solving. Alan Turing, the British mathematician who broke the enigma code, wrote the first ones.[69] They are a step-by-step set of operations, and can be as simple as the rules for adding two-digit numbers. In its original form, programmers had to define the task accurately and completely. This is limiting, as tasks like translation are too complex for definition.[70]

Some algorithms now allow computers to learn on their own, called machine learning.[71] This type of AI is the process by which algorithms improve their own performance.[72] Programmers train the algorithm with large data sets, say hundreds of thousands of images, that permit it to learn a task, as simple as the spam filters for email.[73] The software then creates rules on how to analyze new data. Some uses include Facebook's news feed,[74] and data mining, used for directed marketing. The software corrects itself through trial and error, made rapid with current computing power.[75] It discovers which answer has the highest probability of being right.[76] It first showed its promise in a demonstration identifying cats in YouTube videos.

Deep learning is an advanced form of machine learning that requires less programmer intervention, and is inspired by the way the brain understands new information. It developed Google Translate,[77] facial recognition, driverless cars, and [Slide18] won Go, the most complicated board game, against the world champion.[78] It learned strategy by analyzing hundreds of thousands of games and playing millions against itself. [79]

No one could program computers to accomplish this,[80] and in fact the programmers don't know how the algorithm works. "They are difficult (sometimes impossible) to understand, tricky to debug, and harder to control….. As these networks receive data on whether they are generating good results or not, they update their weights with the goal of improving the results."[81] Researchers are now trying to reverse engineer the process, to find out where a choice was made, and how much it influenced the results.[82] This is important work, as some algorithms make racially biased decisions, and others will choose military targets.[83] Machine learning software, based on deep learning, is beginning to be used to design other such software—so software designers, too, will lose jobs.[84] This is a promising research effort of the Google Brain research group.[85]

Google translate was highly inaccurate and almost useless when it was launched in 2006. The latest version is a smartphone app that permits both typing and speaking text. The user can then either read or hear the answer. Not yet perfect, it's a boon to travelers who don't know Bengali, Czech or Yoruba or others of more than 100 languages. Scanning text with the phone's camera permits reading street signs, all for free. Its improvement shows off deep learning. Translate has absorbed "gigantic quantities of parallel texts." One particularly good source has been the European Union's official publications, which are translated into all member languages.[86] The system translates not only what it has been directly instructed to do, but once it could translate English into Korean and back, as well as English to Japanese, it was able to translate Korean directly into Japanese.[87]

[Slide19] Here are three versions of a passage of Hemingway. The first is a translation from the Japanese done before the recent advance; the second is Hemingway, and the third is the current version of Translate, almost perfect, with a few exceptions in red.

So, then, which jobs are expected to continue as the province of us humans, at least for a while? Some household activities will continue, just as washing machines replaced hand-washing clothes without eliminating the job, and robot vacuum cleaners still require some human aid.[88] Few jobs were lost. Some computer functions create jobs just as music recording did not replace musicians; it rather provided more jobs.

The authors[89] of the previously mentioned Oxford study estimated the impact on a range of several hundred occupations. Routine jobs, like data processing, or data collecting, are threatened; those involving human interaction or social intelligence are not.[90] They conclude that the least likely to lose jobs are workers like Recreational Therapists, Emergency Management Directors, psychiatric Social Workers, and Audiologists. Most likely are Insurance Underwriters, Title Examiners, bookkeepers, and Telemarketers.[91]

As jobs of the future will increasingly be those that computers cannot perform,[92] what human skills are most difficult to replace? Brynjolffson and Mcafee describe three areas where humans still beat machines, and are key to job creation:

Creative endeavors: like writing, entrepreneurship, and scientific discovery. Computers may do better with modern art and contemporary music, some of which could already be computer-generated. Since the 1990's. computers have written music in the style of Bach, and painted in the style of Picasso.[93] A computer helped write an English musical.[94] *The Guardian* review reported that "it sounds just like a musical composed by a computer."[95]

Social interactions: pretty much everyone agrees that the least likely jobs to be replaced are those in the care professions, especially childcare. Negotiations or interpersonal communication are most difficult for robots as they depend on tacit knowledge. People sensitive to the needs of others make good managers, leaders, salespeople, negotiators, caretakers, nurses, and teachers. Consider, for example, a robot giving a pep talk to a football team, or to a child worrying about an exam. The demand for these social skills favors women. Jobs for those with high levels of both cognitive skill and social skill are expanding.[96] Robot reasoning power is limited to what is contained in their software, so that robots can't deal with conditions for which they do not have instructions.[97]

Physical dexterity and mobility: even a child is clever at picking up a pencil compared to a robot. Humans have hiked mountains, swum lakes, and danced for millenia—giving us great agility and physical dexterity. Gardening and housekeeping, which require these kinds of skills, are currently not well done by robots. A robot probably can't take over the work of a skilled hair cutter, which combines dexterity with creativity. However research is overcoming problems of physical dexterity by using human-robot interaction. The human operator sees what the robot sees through special googles, and then makes the movements wanted of the robot. This is useful for disaster intervention, like operating in a toxic environment.[98]

Though digital assistants are a marvel, they fall short in important ways that illustrate human gifts not yet shared with robots. These include the range of human speech and knowledge of what it means. The AI expert who worked on a forerunner of Siri describes such assistants as "frustratingly limited." They might not achieve this capability until computers match human intelligence. Devices that serve fewer uses seem to function better, ones like Amazon's Echo, that responds to questions or arranges purchases.[99]

Machines threaten more than jobs and privacy: Cathy O'Neill, a critic of sole reliance on computer models, warns, "big data increases inequality and threatens democracy…. Decisions [on]—where we go to school, whether we get a car loan, how much we pay for health insurance—are being made …by mathematical models. In theory, this should lead to greater fairness: Everyone ...judged ...[by]the same rules…. But… the opposite is true. The models …are opaque, unregulated, and uncontestable…. Most troubling, they reinforce discrimination: …"[100] An example: "in Florida, adults with clean driving records and poor credit scores paid an

average of $1552 more [for auto insurance] than [similar] drivers with excellent credit and *a drunk driving conviction*."[101]

Teacher assessments by computer have varied widely from one year to another. One experienced teacher got scores of 6, then 96 the next year with no change in pedagogy, threatening her job. Evaluating criminal defendants with algorithms rather than a judge raises serious issues. The data input comes partly from police reports, often race-biased. The other source, usually a questionnaire, also poses problems. Some ask defendants for their family history of trouble with the law, unconstitutional if asked in court. When embedded in a defendant's score, it is considered "objective."[102] Other algorithms wait for a weather forecast before setting work schedules, making it impossible for workers to plan for childcare, schooling, or a second job.[103]

As we hand more tasks to computers, we experience greater disruption from their malfunction. The prejudice and faulty perception of those who write algorithms, though obscured, can affect millions. For example, a Harvard PhD with an African-American name was shocked to come up with a Google search with ads asking, "Have you ever been arrested?"—ads not appearing for white colleagues. Her study found that Google's algorithm was inadvertently racist—it linked names likely for black people to ads relating to arrest records.[104] [Slide 20] Algorithms can easily encode prejudice and misunderstanding, like these images of "unprofessional hairstyles"[105] featuring predominantly black models. [The problem is even worse: algorithms developed from masses of data fed into them reflect cultural biases of race and sex—far more difficult to offset.[106]]

Despite their power over our lives, their verdicts are beyond appeal, and frequently punish the poor.[107] MacDonalds is more likely to use them to choose employees than Goldman Sachs. Computer expert Pedro Domingos says, "People worry that computers will get too smart and take over the world, but the real problem is that they're too stupid and they've already taken over the world."[108] Computer decision-making has the potential to overcome individual prejudice, like that of judges, but only if algorithms are transparent and there is some scope for changing them to correct their shortcomings. There is some attempt now to do this.[109]

There are other problems with computer decisions. Facial recognition, for example, is useful for verifying some financial transactions. Facebook, Instagram, and Twitter have already given access to a surveillance company that markets to law enforcement as a tool targeting activists and protestors.[110] An FBI Database including photos of half of US adults has a nearly 15% error rate, and is more like to misidentify black people.[111] "The conclusions of any automated system ultimately depend on the judgments of human reviewers to evaluate and verify that the correct subject is present in the computer's list of possible matches." [112] [SLIDE21] Carnegie-Mellon researchers used glasses costing 22 cents to fool facial recognition systems. These rely on facial details, like the shape of a nose. The glass frames were printed with patterns read by the computer as details of another person. This achieved up to 100% success in misidentification. In one

test, a white male subject was identified as "actress Milla Jovovich with 88% accuracy. Other notable figures whose faces were stolen include …Colin Powell, and John Malkovich."[113]

Consider the decisions that must be built into self-driving cars: who should be sacrificed if a choice must be made in an impending accident? We have no way yet to incorporate choices that satisfy both our moral code and self-interest. People want other drivers to use ethics codes that could sacrifice passengers, but they want cars that protect themselves at all costs.[114] Not to mention thwarting mischievous hackers,[115] and dealing with pedestrians, who know that cars will yield, and tie up traffic by ignoring signals.[116]

Then there is the issue of spurious search results. [Slide22] A student asked a history professor whether Warren Harding had been in the Ku Klux Klan. The professor was mystified until another student pulled up a report[117] headlined, "Google's Featured Snippets Are Worse than Fake News." The problem stems from a system change to give direct answers to questions above the usual list of web pages. Mass murderer Dylann Roof claimed a Google search on "black on white crime" led him to massacre nine people in a South Carolina church. Matches on "black on white crime" rather than "statistics on crime rates by race" give links to racist sites with their own facts. A search for "who really killed JFK" will frequently lead to conspiracy sites[118] Philosopher Daniel Dennett recommends that AI developers be licensed and forced to accept liability for their product. This would force them to divulge their known weaknesses, just as drug companies list side effects."[119]

As previously noted, productivity growth has slowed while technological change is faster.[120] Robert Solow's 1987 quip still holds: "You can see the computer age everywhere but in the productivity statistics." Economist Dani Rodrik sums up: "… who can seriously doubt that innovation is progressing rapidly? The debate is about whether these innovations will remain bottled up in a few tech-intensive sectors that employ the highest-skilled professionals and account for a relatively small share of GDP, or spread to the bulk of the economy." His answer to the productivity paradox is that technology's major impact has been on media, information and communications technology. These don't employ a major part of the labor force and so far affect less than 10% of output. [121] The average American spends more than a fifth[122] of waking hours watching tv or using their computer for leisure, like gaming. "The robots aren't taking our jobs; they're taking our *leisure."*[123] Innovation has had little effect so far where consumers spend the most, like health, education, transportation, and housing. Government and health care, for example, have had almost no productivity growth. These two sectors account for more than a quarter of output.[124] Until technology spreads, the consequences for workers will be limited.

How limited? Two important studies relating to manufacturing jobs have come from MIT researchers. A study of the impact of industrial robots in manufacturing concludes that between 1990 and 2007, the relatively few industrial robots reduced US employment by an estimated 360 to 670 thousand workers.[125] By comparison, another analysis estimated that between 1999 and 2011, Chinese imports cost the U.S. about 2.4 million jobs—about 985 thousand in manufacturing. This is about 17% of the 5.8 million manufacturing jobs

that the U.S. lost in total in that time, and an even higher share of the manufacturing job level that preceded the financial crisis in late 2007-2008.[126]

Unfortunately, our data sources have not yet caught up to changes in production created by computers, especially in services. The delinking of productivity change and employment is a possible sign that Computers have replaced secretaries and information call workers; online sales are cutting retail trade, and traditional news sources are competing with online publications. However, we have not yet good measures of how many jobs are affected and where, or what other changes are in process. An expert committee, including Brynjolffson, Acemoglu and others, has called for tracking and predicting the job impact of these changes in technology. [127]

Should we worry about a rapid transition? [128] Economist Robert Gordon dismisses technology as a major force of change.[129] He describes its impact in medicine as merely a one-time shift to electronic records, and notes fewer approvals of new drugs. Robots are useful primarily in manufacturing, which accounts for only eight percent of U.S. employment; warehouses, a little more. Robots won't soon replace us in services or construction. Offices and stores use computers much as they have for years. Many current innovations, like the smartphone, mostly entertain and distract, he notes, and the financial crisis has further slowed growth.[130]

Some contest our productivity measure. Free services from Google, Spotify and others are paid for by advertising, not consumers, so are not fully counted. The free digital economy is valued at production cost, so underestimated.[131] Others challenge the mismeasurement thesis,[132] as there have been parallel slowdowns in many countries, with varying engagement in the digital economy.[133] They point to new costs, like a cell phone and internet connection, necessary because everyone you know is connected and public phones don't work, or antivirus programs, unnecessary before we were on-line.[134]

Finally, some researchers point to the limited presence of robots. They make up slightly over 2 per cent of the capital stock, less than earlier major technologies, but this excludes software.[135] Here we might cite the preference of the financial sector for consumer apps like Snapchat over hardware. Some startups reported that "Chinese money was sometimes the only available funding."[136] An *Economist* editor[137] has a good take on the issue: low wages and a weak safety net account for both weak consumer and limited business spending. Low wages inhibit investing to improve productivity. Minimum wages are below their level 50 years ago, and men's median wages have been stagnant[138] nearly as long. It is not only the cost of capital—overhauling systems to use robots is complicated and risky. "While labour is cheap, firms face little pressure to make those massive investments in intangible capital."

Joel Mokyr, an economic historian of technology, sees a future of rapid change. We are likely to acquire new tools and instruments allowing us to perceive the formerly invisible. Better tools are responsible for our current advances in astronomy, nanochemistry, and genetic engineering. Then there are the improvements in search: from libraries and indexes to searchable databases. We can copy, transmit, and search vast stores of data nearly free. "Scientists can now find the tiniest needles in data haystacks …in a fraction of a second."[139]

Change is unremitting as each new solution disturbs something else—like the effects of oil on transportation and the plastics industry, and on the downside, on the environment. With the disruption, there will also be new jobs for new tasks. Who anticipated video game programmers in 1960? social media consultants? a pet industry providing therapy, surgical services, and vacations? And some not so good jobs: cell phones empowered drug dealers; some new jobs fight new forms of crime, like cyber-fraud, computer hacking, and unwanted phone calls.[140]

David Autor, a labor economist at MIT and his co-authors have found the net effect on jobs to be slight, though technology has polarized the labor market, expanding jobs for the educated and increasing earnings inequality. [Slide23] However, though workers are often blamed for lacking skills, the left of the slide shows evidence of over-supply of educated workers, with falling median wages in the sciences between 2010 and 2014, and on the right, nearly 40% of new PhD's idle in 2014. [Slide24 The role of education either in explaining unemployment or protecting jobs is much exaggerated: in 2014, nearly 64% of jobs, highlighted, required only a high-school degree or less, according to the Bureau of Labor Statistics, though jobs requiring at least a college degree are projected to grow faster.[141] Wages for college graduates 22 to 26 years old fell for all areas of study, including the sciences, since the financial crisis, with only stable, not rising, wages available to those with experience, ages 35 to 54.[142] Two-thirds of job postings for executive secretaries[143] and assistants require a bachelor's degree, though only 19 percent of workers currently doing that work have them.[144] [Slide25] Over 50% of college graduates 22 to 65 years old are in jobs not requiring a college education, some in "good," others in low-wage jobs. A "good" job is described as paying at least $45 thousand, a rather low bar. Rising requirements and a preference for college degrees seem to reflect weak job markets more than real job requirements.

Along with Chinese imports, technology and weak labor markets have imposed serious losses on our workers.[145] It hasn't helped that consumer spending and business investment, undermined by the financial crisis, inequality and the austerity mania, have slowed recovery. In another study, Autor and colleagues find that competition from Chinese imports reduced US firms' research spending, global sales and jobs in manufacturing, a major source of innovation. Computer and semiconductor growth masked poorer outcomes elsewhere in manufacturing. [146] One global expert jokes that that the main difference between the US and China is not capitalism vs communism. "It is that one is run by lawyers and the other by engineers," shown in the explosion of digital technologies ...[in] the daily lives of hundreds of millions of... Chinese consumers."[147]

Autor[148] agrees with McKinsey: most jobs demand a variety of skills, so that labor will still be necessary. As robots eliminates some skills, they raise the importance of others, as bank tellers were converted to sales and customer service.[149] It is likely that in the future, too, we'll have occupations beyond our current imagining. The upheavals expected by some are denied by others, who believe new jobs will replace old ones,

and new technology will create new needs and the jobs needed to satisfy them, like cell phones.[150] The question remains, will the new jobs absorb the whole work force?

Scientist Stephen Hawking is fearful:

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> If machines produce everything we need, the outcome will depend on how things are distributed. Everyone can enjoy a life of luxurious leisure if the machine-produced wealth is shared, or most people can end up miserably poor if the machine-owners successfully lobby against wealth redistribution. So far, the trend seems to be toward the second option....[151]

The *New Yorker*'s Elizabeth Colbert[152] warns, "if it's unrealistic to suppose that smart machines can be stopped, it's probably just as unrealistic to imagine that smart policies will follow." Though our vision of the future is restricted, rising output tends to accelerate climate change, and engulf us with garbage. However, our problem is politics; not technology. Our political system could plan for those deprived of a job, *either* as growth lags *or* innovation speeds up.[153] Many problems like global warming require government investment and subsidy, and profitable investments would blossom in a rational world. The failure of vision of what public investments are needed, both in research and structures, has trapped us in planet-threatening problems with no political solutions in sight. The prospect of robots taking over much work, especially the drudge or dangerous work that people must do to survive "should fill us with joy."[154] Our economic system and narrow vision currently hinder devising ways of distributing the new wealth to make this a challenge rather than a disaster.

How can we provide for workers displaced across crafts and professions and excluded from gainful employment? Without policies permitting everyone to enjoy the fruits of this new world, we'll have both unsold goods along with the injustice and danger of a super-privileged elite barricaded against a destitute population. President Roosevelt, in his 1944 State of the Union address, recognized that economic rights, like the right to a job, support democratic rights, like the right to vote or free speech. He said, "necessitous men are not free men."

Where are the funds for a generous safety net? Warren Buffett agrees with Herbert Simon[155] that social capital has fueled individual wealth: "I personally think that society is responsible for a very significant percentage of what I've earned. If you stick me down in the middle of Bangladesh or Peru..., you find out how much this talent is going to produce in the wrong kind of soil... I work in a market system that happens to reward what I do very well—disproportionately well." These social benefits –a work force trained with public funds, public infrastructure, global technology created over centuries—are a good reason for generous income transfers. They are clearly necessary, given the economic catastrophe already faced by some: "The increase in death rates among less educated whites since 2001 is roughly the size of the AIDS epidemic."[156]

Many, especially Libertarians, favor a basic income guarantee. If everyone receives it, its cost would be enormous. $10,000 a year for every American, not exactly a life of luxury, would cost an estimated $3 trillion a year[157]—slightly more than all the taxes collected by the federal government in 2016. Even paying only those

over 18 takes $2.5 trillion. In some versions, it tapers off after a maximum. Some conservatives who support it, like Charles Murray, propose funding it by eliminating all other safety net programs, including Medicare, Medicaid, Social Security, agricultural subsidies, and corporate welfare.[158] This would yield a meager income.

Payroll or even income taxes can't fund it as these will fall with jobs.[159] [Slide26] Bill Gates proposes taxing robots,[160] already planned by the European Union. Another proposal is that "any company that uses the internet... should ...pay a perpetual... royalty to the population that developed and funded it. Same goes for roads, electricity, integrated circuits, etc."[161] Guaranteed income, then, could grow along with the spread of robots, ensuring that benefits are broadly distributed. This makes more sense than taxing robots. Robot-generated profits are supported partly by government sponsored research.[162] For example, my Roomba vacuum cleaner uses an algorithm similar to the bomb disposal robot built for the Defense Department.[163] The inventor of Roomba also invented the robot Baxter. A 1980's military project, the Autonomous Land Vehicle, was the source for the driverless car.[164] Having society share in profits from government-sponsored research is a sensible income source.

There are other choices: A good first step is reducing our work week and work year, which are currently among the longest in the industrial world. We could begin with annual holidays—what about a month? Then shorter work hours, beginning with very stressful jobs. For many, work has become more intense, and this combined with extensive monitoring makes for an unpleasant workplace.

Brynjolfsson and McAfee like conservative economist Milton Friedman's negative income tax, favored by President Nixon. This preserves a work incentive by supplementing income from work, up to a maximum.[165] They quote Voltaire: "Work saves a man from three great evils: boredom, vice and need." Their preference, which I share, is for programs similar to the New Deal that restored the environment and provided infrastructure and other public goods. We need work that heals the planet—jobs that include restoring our waters, recycling wastes, replacing fossil fuels, and finding alternatives to other noxious products. We also need to provide the full range of services for those who need them as well as to support generously the arts that nourish us. Those without work, in an economy structured like ours, will lose social status. So long as there are jobs that need doing,[166] we should favor guaranteed work, especially with adequate vacations, limited work time, and support for life-long learning. There are some good choices.//

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[1] http://www.chicagotribune.com/bluesky/technology/ct-artificial-intelligence-google-brin-blm-bsi-20170119-story.html "A **robot** is a machine designed to execute one or more tasks automatically with speed and precision."

[2] http://www.epi.org/publication/robots-or-automation-are-not-the-problem-too-little-worker-power-is/

[3] https://www.cognizant.com/whitepapers/the-robot-and-I-how-new-digital-technologies-are-making-smart-people-and-businesses-smarter-codex1193.pdf and http://seekingalpha.com/article/3965499-hedge-fund-employs-robot-analysts-pick-stocks-financial-advisors-daily-digest

[4] What the AI Behind AlphaGo Can Teach Us About Being Human, http://www.wired.com/2016/05/google-alpha-go-ai/

[5] http://www.businessinsider.com/wef-davos-report-on-robots-replacing-human-jobs-2016-1
[6] Digital America, 75 http://www.mckinsey.com/industries/high-tech/our-insights/digital-america-a-tale-of-the-haves-and-have-mores
[7] https://www.foreignaffairs.com/press/2015-06-16/hi-robot-foreign-affairs-explores-what-s-next-age-automation-its-julyaugust-issue
[8] https://www.foreignaffairs.com/articles/2015-06-16/robots-are-coming [my files]
[9] *Race Against the Machine* 2014
[10] "…by the mid-2000s labor productivity growth had slowed down to pre-1996 levels, and it has stayed relatively low since then," "many aspects of digital progress aren't counted in GDP. For instance, Wikipedia, unlike the old print version of Encyclopaedia Britannica, is free. That means that… it isn't included in GDP calculations…". https://hbr.org/2015/06/the-great-decoupling
[11] https://hbr.org/2015/06/the-great-decoupling
[12] http://ebusiness.mit.edu/research/Briefs/Brynjolfsson_McAfee_Race_Against_the_Machine.pdf Some recommend a "citizens' dividend." http://www.huffingtonpost.com/mike-sandler/citizens-dividends-basic-_b_1936182.html
[13] Christophe Degryse, https://www.socialeurope.eu/2016/02/here-are-the-new-social-risks-of-the-fourth-industrial-revolution/
[14] https://www.google.com/patents/US7369686 apparently includes pure AI, like facial recognition https://www.weforum.org/agenda/2016/05/the-rise-of-the-robots-how-the-market-is-booming
[15] http://www.nytimes.com/2013/01/25/business/as-graduates-rise-in-china-office-jobs-fail-to-keep-up.html
[16] http://www.ubergizmo.com/2017/01/iphone-manufacturer-foxconn-replace-all-human-workers-with-robots/
[17] "Robots are used in jobs hazardous to human health, such as polishing, welding and moving heavy freight." Govt policies http://www.scmp.com/lifestyle/technology/science-research/article/1754165/robotics-industry-booming-guangdong-insiders
[18] qz.com/599508/charted-chinas-rapidly-shrinking-working-age-population/
[19] http://www.wsj.com/articles/chinas-factories-count-on-robots-as-workforce-shrinks-1471339805
[20] http://www.dcvelocity.com/articles/20161122-china-doubles-down-on-robotics-purchases/ and https://www.technologyreview.com/s/601215/china-is-building-a-robot-army-of-model-workers/
[21] http://learnmore.economist.com/story/57ad9e19c55e9f1a609c6bb4
[22] http://issues.org/30-3/stuart/ See an advanced strategy for counseling workers threatened by robots: https://www.fastcoexist.com/3067875/creating-career-advice-for-the-about-to-be-automated-worker
[23] https://hbr.org/2014/12/what-happens-to-society-when-robots-replace-workers
[24] http://quoteinvestigator.com/2011/11/16/robots-buy-cars/
[25] "Information technology fueled a surge in U.S. productivity growth in the late 1990s and early 2000s. However, this rapid pace proved to be temporary, as productivity growth slowed before the Great Recession." http://www.frbsf.org/economic-research/publications/economic-letter/2015/february/economic-growth-information-technology-factor-productivity/
[26] "Artificial Intelligence, Automation, and the Economy," https://www.whitehouse.gov/sites/whitehouse.gov/files/documents/Artificial-Intelligence-Automation-Economy.PDF It has averaged roughly 1% a year for the last decade, compared to almost 3% from 1947 to 1973 and 1995 to 2005. http://cepr.net/publications/op-eds-columns/badly-confused-economics-the-debate-on-automation
[27] https://www.emptywheel.net/2016/03/14/the-problem-of-the-liberal-elites-part-1/
[28] https://www.theguardian.com/technology/2016/may/20/silicon-assassins-condemn-humans-life-useless-artificial-intelligence
[29] "Technology at work: How the digital revolution is reshaping the global workforce," Carl Benedikt Frey, Ebrahim Rahbari 3/25/16 http://www.voxeu.org/article/how-digital-revolution-reshaping-global-workforce
[30] http://www.economist.com/news/leaders/21701119-what-history-tells-us-about-future-artificial-intelligenceand-how-society-should https://www.socialeurope.eu/2015/10/how-technology-can-eradicate-unemployment-and-jobs-at-the-same-time/
[31] UNIVAC to Census Bureau 1952 http://www.computerhistory.org/timeline/computers/ Digitally controlled industrial robots and robots making use of artificial intelligence have been built since the 1960s. Wikipedia
[32] http://www.ft.com/cms/s/0/cb4c93c4-0566-11e6-a70d-4e39ac32c284.html#ixzz49mNOrFW0
[33] http://www.economist.com/news/special-report/21700761-after-many-false-starts-artificial-intelligence-has-taken-will-it-cause-mass
[34] http://www.defenddemocracy.press/its-the-robots-stupid/
[35] http://www.computerworld.com.au/article/594562/u-sees-robots-taking-well-paying-jobs/ 51% earned $20/hr or less [2014] http://www.marketwatch.com/story/a-majority-of-americans-make-less-than-20-per-hour-2014-11-14
[36] Frey and Osbourne http://www.oxfordmartin.ox.ac.uk/downloads/academic/future-of-employment.pdf
[37] http://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/four-fundamentals-of-workplace-automation
[38] http://www.mckinsey.com/business-functions/business-technology/our-insights/four-fundamentals-of-workplace-automation
[39] https://www.technologyreview.com/s/603370/robots-will-devour-jobs-more-slowly-than-you-think/ and *The Future of the Professions: How Technology Will Transform the Work of Human Experts*
[40] http://www.vice.com/read/every-job-could-be-a-casualty-of-the-robot-revolution
[41] https://www.asme.org/engineering-topics/articles/technology-and-society/robots-at-work-where-do-we-fit
[42] https://hbr.org/2014/12/what-happens-to-society-when-robots-replace-workers which references http://rsif.royalsocietypublishing.org/content/11/96/20140303 on knee scans.
[43] https://www.technologyreview.com/s/601378/nimble-fingered-robot-outperforms-the-best-human-surgeons/
[44] https://mishtalk.com/2016/09/10/sports-writer-robots-will-an-ai-robot-writer-win-a-pulitzer-prize/

[45] http://spectrum.ieee.org/the-human-os/biomedical/devices/the-tiny-robots-will-see-you-now
[46] http://www.apa.org/monitor/2015/06/robo-therapy.aspx
[47] http://www.h-n-h.jp/en/ http://www.vice.com/read/japan-is-opening-a-hotel-staffed-almost-entirely-by-robots
[48] https://www.project-syndicate.org/commentary/temporary-robot-tax-finances-adjustment-by-robert-j--shiller-2017-03
[49] https://www.theguardian.com/technology/2016/jun/17/self-driving-trucks-impact-on-drivers-jobs-us
[50] https://qz.com/943899/a-timeline-of-when-self-driving-cars-will-be-on-the-road-according-to-the-people-making-them/
[51] https://www.nextrembrandt.com/
[52] http://www.donotpay.co.uk/
[53] https://www.theguardian.com/technology/2016/jun/28/chatbot-ai-lawyer-donotpay-parking-tickets-london-new-york
See also http://venturebeat.com/2016/06/27/donotpay-traffic-lawyer-bot/
[54] https://www.theguardian.com/technology/2017/mar/06/chatbot-donotpay-refugees-claim-asylum-legal-aid
[55] http://www.bloomberg.com/news/articles/2016-06-30/robots-are-taking-divorce-lawyers-jobs-too
[56] http://religion.blogs.cnn.com/2011/02/09/vatican-issues-warning-for-new-confession-app/
[57] https://www.ft.com/content/f1ec9d80-2a15-11e5-8613-e7aedbb7bdb7
[58] https://www.technologyreview.com/s/603431/as-goldman-embraces-automation-even-the-masters-of-the-universe-are-threatened/
[59] http://diginomica.com/2016/11/17/an-optimistic-view-of-bot-driven-automation-on-the-future-of-jobs/
[60] https://www.bloomberg.com/news/articles/2017-02-28/jpmorgan-marshals-an-army-of-developers-to-automate-high-finance
[61] http://science.howstuffworks.com/baxter-robot1.htm robot's software is based on ROS (Robot Operating System), an open source ...OS which includes a specialized set of drivers, libraries etc for programming robots, &..Open Source Computer Vision Library, ...that includes computer vision and machine learning algorithms. http://science.howstuffworks.com/baxter-robot2.htm
[62] http://spectrum.ieee.org/robotics/industrial-robots/rethink-robotics-baxter-robot-factory-worker
[63] https://www.quora.com/Why-does-Baxter-the-robot-fail-as-a-manufacturing-tool "less than 400 Baxter robots shipped in 2015. Since the company began shipping...in 2012 ... between 850 & 900 Baxter robots have been installed worldwide. At least 40% of sales...to research labs and univs." https://robotenomics.com/2016/01/11/the-facts-about-co-bot-robot-sales/
[64] https://www.foreignaffairs.com/articles/2016-06-13/human-work-robotic-future
[65] CGP Grey https://youtu.be/7Pq-S557XQU?t=4m30s
[66] http://amturing.acm.org/award_winners/simon_1031467.cfm
[67] http://www.computerworld.com/article/2906336/emerging-technology/what-is-artificial-intelligence.html
[68] http://www-formal.stanford.edu/jmc/whatisai/node3.html
[69] https://www.wired.com/insights/2014/09/artificial-intelligence-algorithms-2/
[70] https://www.nytimes.com/2016/12/14/magazine/the-great-ai-awakening.html
[71]"Facebook's news feed uses machine learning in an effort to personalize each individual's feed based on what they like. The main elements of traditional machine learning software are statistical analysis and predictive analysis used to spot patterns and find hidden insights based on observed data from previous computations without being programmed on where to look.... compared to deep learning ... it requires manual intervention in selecting which features to process... deep learning does it intuitively.... to use machine learning for computer vision, you need image processing experts to tell you what are the few (tens or hundreds) of most important features in an image. But if you use deep learning for computer vision, you just feed in the raw pixels, without caring much for image processing or feature extraction, which offers 20-30 percent improvement in accuracy in most computer vision benchmarks.For example, assume you saw a clear image of a dog, and assume that if the pixels of the image were modified just a few per cent, it is still easily recognized that there is a dog in the image." https://betanews.com/2016/12/12/deep-learning-vs-machine-learning/
[72] https://www.wired.com/insights/2014/09/artificial-intelligence-algorithms-2/
[73]"...AI has exploded, and especially since 2015. Much of that has to do with the wide availability of GPUs that make parallel processing ever faster, cheaper, and more powerful. It also has to do with ... practically infinite storage and a flood of data ...Big Data movement)" https://blogs.nvidia.com/blog/2016/07/29/whats-difference-artificial-intelligence-machine-learning-deep-learning-ai/
"Machine learning algorithms come in two main flavors: supervised and unsupervised. Supervised algorithms need a teacher (us). A spam filter learns what spam is by generalizing from example emails that have been labeled "spam" or "not spam." Most learning algorithms in use today are of this variety. Big data makes them very powerful—lots of examples to learn from—but they learn to do one very specific job at a time…. Unsupervised algorithms learn on their own, like children at play, but even they are guided by a control signal…. And the control signal is determined by us." https://medium.com/@pedromdd/ten-myths-about-machine-learning-d888b48334a3
[74] https://betanews.com/2016/12/12/deep-learning-vs-machine-learning/
[75]http://www.slate.com/articles/technology/bitwise/2015/09/pedro_domingos_master_algorithm_how_machine_learning_is_reshaping_how_we.html
[76] AlphaGo's historic victory against one of the best Go players of all time, Lee Sedol, a landmark for AI, and especially for "deep reinforcement learning.""[it] takes inspiration from [how] animals learn that certain behaviors tend to result in a positive or negative outcome. Using this, a computer can, eg, figure out how to navigate a maze by trial and error and then associate the positive outcome—exiting the maze—with the actions that led up to it. so a machine learns without instruction or even explicit examples. The idea is not new, but combining it with large (or deep) neural networks provides the power needed to make it work on really complex

problems (like Go). Through relentless experimentation, as well as analysis of previous games, AlphaGo figured out for itself how play the game at an expert level." https://www.technologyreview.com/s/603216/5-big-predictions-for-artificial-intelligence-in-2017/
[77] http://techreport.com/news/30722/google-translate-gets-a-boost-from-deep-neural-networks and http://www.nature.com/news/deep-learning-boosts-google-translate-tool-1.20696
[78] "…official commentator Michael Redmond added that the South Korean professional had "played his best". Lee himself couldn't disagree more. Speaking through a translator, he apologized for his play in this third game. Lee Sedol said that he'd never felt as much pressure as he did in game 3. And while he had identified missed opportunities in game 2, he felt he could not win game even if he replayed it today. ….Lee had lost the third game very early, by move 35. (A DeepMind scientist who was passing at the time said that this was in agreement with AlphaGo's internal evaluation of its winning chances). http://www.nature.com/news/the-go-files-ai-computer-clinches-victory-against-go-champion-1.19553
[79] https://www.technologyreview.com/s/602094/ais-language-problem/ "A software engineer would write a thousand if-then-else statements [to identify a dog]: *if* it has ears, and a snout, *and* has hair,. . . and etc. But that's not how a child learns.... ...she learns by seeing dogs and being told that they are dogs, makes mistakes, corrects herself. She thinks that a wolf is a dog—but is told that it belongs to an altogether different category. And so she shifts her understanding bit by bit: this is 'dog,' that is 'wolf.' The machine-learning algorithm, like the child, pulls information from a training set:... Here's a dog, and here's not a dog. It then extracts features from one set versus another. And, by testing itself against hundreds and thousands of classified images, it begins to create its own way to recognize a dog—again, the way a child does."http://www.newyorker.com/magazine/2017/04/03/ai-versus-md" April 3, 2017, issue, with the headline "The Algorithm Will See You Now."
[80] http://fortune.com/ai-artificial-intelligence-deep-machine-learning/
[81]http://www.slate.com/articles/technology/bitwise/2015/09/pedro_domingos_master_algorithm_how_machine_learning_is_reshaping_how_we.html
[82]https://www.technologyreview.com/s/603795/the-us-military-wants-its-autonomous-machines-to-explain-themselves/ funded mil.
[83] https://blogs.nvidia.com/blog/2016/07/29/whats-difference-artificial-intelligence-machine-learning-deep-learning-ai/
http://www.militaryaerospace.com/articles/2015/07/hpec-radar-target-recognition.html
http://www.sciencemag.org/news/2017/03/brainlike-computers-are-black-box-scientists-are-finally-peering-inside
[84] https://www.technologyreview.com/s/603381/ai-software-learns-to-make-ai-software/
[85] https://www.technologyreview.com/s/603381/ai-software-learns-to-make-ai-software/
[86] http://www.lrb.co.uk/v37/n05/john-lanchester/the-robots-are-coming
[87] https://techcrunch.com/2016/11/22/googles-ai-translation-tool-seems-to-have-invented-its-own-secret-internal-language/
[88] https://hbr.org/2016/12/wall-street-jobs-wont-be-spared-from-automation
[89] www.oxfordmartin.ox.ac.uk/downloads/academic/The_Future_of_Employment.pdf
[90] http://www.lrb.co.uk/v37/n05/john-lanchester/the-robots-are-coming and http://www.businessinsider.com/jobs-that-robots-will-take-2016-8
[91] http://www.vice.com/read/every-job-could-be-a-casualty-of-the-robot-revolution
[92] http://www.forbes.com/sites/markcohen1/2016/09/06/artificial-intelligence-and-legal-delivery/
[93] http://www.vice.com/read/can-machines-write-musicals
[94]sorted through 2,000 musicals looking for patterns separating hits from flops: best bet would be set in Europe in the 1980s, have a female star, and concern war. Each act begins with an energetic musical number, a death halfway through the second act, & a strong comedy section. Computer then generated various plots. The team just embroidered additions like emotional dialogue. Computer created music and lyrics. http://www.telegraph.co.uk/theatre/what-to-see/beyond-the-fence-arts-theatre-review-computer-says-so-so/
[95] https://www.theguardian.com/stage/2016/feb/28/beyond-the-fence-review-computer-created-musical-arts-theatre-london
[96] https://scholar.harvard.edu/files/ddeming/files/deming_socialskills_august2015.pdf
[97] https://www.foreignaffairs.com/articles/2015-06-16/robots-are-coming
[98]Marc S. Lavine *Science* 23 Sep 2016: V. 353, Iss. 6306, pp. 1378-1379 http://spectrum.ieee.org/automaton/robotics/robotics-hardware/mit-humanoid-robot-teleoperation-dynamic-tasks http://www.bbc.com/news/technology-34175290
[99] Richard Waters www.ft-weekend/looking-and-learning/bnl-ftweekend-20160924-75077
[100] https://weaponsofmathdestructionbook.com/ https://www.technologyreview.com/s/602933/how-to-hold-algorithms-accountable/
[101] https://blogs.scientificamerican.com/roots-of-unity/review-weapons-of-math-destruction/
[102] "Software that helps judges decide whether to jail a defendant while they await trial could cut crime and reduce racial disparities amongst prisoners" https://www.technologyreview.com/s/603763/how-to-upgrade-judges-with-machine-learning/
[103] https://phys.org/news/2017-02-algorithms-secretly-world.html
[104] https://www.wired.com/2014/11/algorithms-great-can-also-ruin-lives
[105] https://www.theguardian.com/science/2016/sep/01/how-algorithms-rule-our-working-lives Cathy O'Neill
https://www.jacobinmag.com/2016/09/big-data-algorithms-math-facebook-advertisement-marketing/
[106]See https://www.technologyreview.com/s/602950/how-to-fix-silicon-valleys-sexist-algorithms/ The research: "... machines can learn word associations from written texts and that these associations mirror those learned by humans....for example, associations between female names and family or male names and career." http://science.sciencemag.org/content/356/6334/183
[107] https://www.theguardian.com/science/2016/sep/01/how-algorithms-rule-our-working-lives https://mathbabe.org/?s=algorithm
https://www.technologyreview.com/s/602933/how-to-hold-algorithms-accountable/

[108] Pedro Domingos, *The Master Algorithm*, quoted, http://boingboing.net/2016/10/13/ais-blind-spot-garbage-in.html
[109] https://www.technologyreview.com/s/603915/tech-giants-grapple-with-the-ethical-concerns-raised-by-the-ai-boom/
[110] https://medium.com/@ACLU_NorCal/police-use-of-social-media-surveillance-software-is-escalating-and-activists-are-in-the-digital-d29d8f89c48#.n6t85ss2u The ACLU of California has obtained records showing that Twitter, Facebook, and Instagram provided user data access to Geofeedia, a developer of a social media monitoring product that we have seen marketed to law enforcement as a tool to monitor activists and protesters. https://www.aclunc.org/blog/facebook-instagram-and-twitter-provided-data-access-surveillance-product-marketed-target
[111] https://www.theguardian.com/technology/2017/mar/27/us-facial-recognition-database-fbi-drivers-licenses-passports
[112] https://theintercept.com/2016/10/13/how-a-facial-recognition-mismatch-can-ruin-your-life/
[113] http://boingboing.net/2016/11/02/researchers-trick-facial-recog.html
[114] http://www.nakedcapitalism.com/2016/10/self-driving-cars-how-badly-is-the-technology-hyped.html
[115] Since AI is a fundamental part of the concept of the Internet of Things, where machines and devices communicate with each other to get the work done, it's only AI and machine learning that will be incredibly useful to defend our network before anyone exploits them.Last year, Security researchers at MIT also developed a new Artificial Intelligence-based cyber security platform, called '**AI2**,' which has the ability to predict, detect, and stop 85% of Cyber Attacks with high accuracy.
http://thehackernews.com/2017/01/artificial-Intelligence-cybersecurity.html
[116] https://www.scientificamerican.com/article/how-pedestrians-will-defeat-autonomous-vehicles/
[117] https://theoutline.com/post/1192/google-s-featured-snippets-are-worse-than-fake-news
[118] https://www.bloomberg.com/view/articles/2017-02-16/do-you-trust-big-data-try-googling-the-holocaust
[119] https://www.ft.com/content/96187a7a-fce5-11e6-96f8-3700c5664d30
[120] http://www.nybooks.com/articles/2016/08/18/why-economic-growth-will-fall/
[121] https://www.project-syndicate.org/commentary/innovation-impact-on-productivity-by-dani-rodrik-2016-06
[122] https://www.bls.gov/TUS/CHARTS/LEISURE.HTM
[123] http://www.vox.com/2015/7/27/9038829/automation-myth
[124] Total spending healthcare 17.8% GDP https://www.cms.gov/research-statistics-data-and-systems/statistics-trends-and-reports/nationalhealthexpenddata/nationalhealthaccountshistorical.html
[125] Acemoglu & Restropo, Robots And Jobs: Evidence From Us Labor Markets, p. 36, http://www.nber.org/papers/w23285
[126] Autor, Dorn, & Hanson, 'The China Shock: Learning from Labor-Market Adjustment to Large Changes in Trade," www.annualreviews.org 2016. 8:205–40
[127] "Information Technology and the U.S. Workforce: Where Are We and Where Do We Go from Here?" http://www.nap.edu/24649 See p. 163 for recommendations.
https://www.nap.edu/download/24649
[128] In 1969, McKinsey expected "that computers were so dumb that they were not capable of making any decisions"--human intelligence "drives the dumb machine." http://www.dataversity.net/ai-vs-machine-learning-vs-deep-learning/
[129] http://blogs.piie.com/publications/papers/gordon20151116ppt.pdf
[130] http://www.nybooks.com/articles/2016/08/18/why-economic-growth-will-fall/
[131] http://www.forbes.com/sites/timworstall/2016/03/31/charlie-bean-says-im-right-but-just-how-right-remains-to-be-seen/ (Goolsbee and Klenow 2006, Brynjolfsson and Oh 2012 etc)
[132] http://blogs.wsj.com/economics/2016/02/12/why-does-u-s-productivity-look-so-abysmal-not-mismeasurement-paper-says/ & http://faculty.chicagobooth.edu/chad.syverson/research/productivityslowdown.pdf "Challenges to Mismeasurement Explanations for the US Productivity Slowdown" 2016.
[133] www.nber.org/papers/w21974.pdf and https://www.brookings.edu/wp-content/uploads/2016/08/syverson.pdf
[134] http://cepr.net/blogs/beat-the-press/mis-measured-growth-will-our-children-be-rich
[135] http://blogs.lse.ac.uk/politicsandpolicy/robots-at-work-the-impact-on-productivity-and-jobs/ [some good measurement]BEA counts software dev as fixed investment
[136] https://www.nytimes.com/2017/03/22/technology/china-defense-start-ups.html
[137] https://medium.com/@ryanavent_93844/the-productivity-paradox-aaf05e5e4aad#.ypwpims0t "Productivity Paradox," Ryan Avent
[138] https://twitter.com/gabriel_zucman/status/806533951875649537
[139] http://voxeu.org/article/technological-progress-thing-past
[140] https://ursulahuws.wordpress.com/2017/01/29/the-future-of-work/
[141] http://www.bls.gov/emp/ep_table_education_summary.htm
[142] https://www.bloomberg.com/news/articles/2017-03-30/u-s-college-grads-see-slim-to-nothing-wage-gains-since-recession
[143] http://www.businessnewsdaily.com/2387-secretary-office-role.html
[144] http://www.businessnewsdaily.com/7103-no-degree-no-job.html
[145] https://www.minneapolisfed.org/publications/the-region/interview-with-david-autor
[146] http://voxeu.org/article/competition-china-reduced-innovation-us
[147] http://www.scmp.com/business/global-economy/article/2081771/be-afraid-china-path-global-technology-dominance
[148] David Autor, Why are there still so many jobs? https://www.socialeurope.eu/2017/03/still-many-jobs/
[149] Why Are There Still So Many Jobs? David Autor, TEDxCambridge, https://www.youtube.com/watch?v=LCxcnUrokJo

[150] https://www.socialeurope.eu/2016/09/robotics-fascination-anthropomorphism/
[151] http://www.huffingtonpost.com/entry/stephen-hawking-capitalism-robots_us_5616c20ce4b0dbb8000d9f15
[152] http://www.newyorker.com/magazine/2016/12/19/our-automated-future
[153] http://www.nakedcapitalism.com/2016/02/satyajit-das-age-of-stagnation-or-something-worse.html
[154] http://www.ianwelsh.net/fixing-the-world-2-moral-calculus/
[155] "In large part, these differences [in incomes within any given society] must be attributed to differences in capital ownership, of which the largest part is social capital: knowledge, and participation in kinship and other privileged social relations." https://bostonreview.net/forum/basic-income-all/herbert-simon-ubi-and-flat-tax The rich are using resources that are significantly social in origin--the technology available to them, the educated workers they depend on, the transportation system, courts, etc they can assume to be available. I think he obscures his general point by adding kinship.
[156]Mortality data from Lancet study: http://www.thelancet.com/journals/lancet/article/PIIS0140-6736(17)30187-3/ppt http://www.politico.com/magazine/story/2016/06/wall-street-2016-donald-trump-hillary-clinton-213931 "In large part, these differences [in incomes within any given society] must be attributed to differences in capital ownership, of which the largest part is social capital: knowledge, and participation in kinship and other privileged social relations..... I personally do not see any moral basis for an inalienable right to inherit resources, or to retain all the resources that one has acquired by means of economic or other activities…..When we compare the poorest with the richest nations, it is hard to conclude that social capital can produce less than about 90 percent of income in wealthy societies like those of the US or Northwestern Europe. On moral grounds, then, we could argue for a flat income tax of 90 percent to return that wealth to its real owners." –Herbert Simon**,** Forum, Boston Review, A Basic Income for All, NJFAC, Quotes from the Advisory Board
[157]Finland will be testing such a program. http://www.nytimes.com/2016/12/17/business/economy/universal-basic-income-finland.html http://federal-budget.insidegov.com/l/119/2016-Estimate
[158] http://www.nationalreview.com/article/436621/universal-basic-income-ubi-terrible-idea
[159] http://www.independent.co.uk/voices/the-basic-income-is-a-dangerous-idea-that-gives-the-state-power-to-control-every-penny-their-a7030391.html
[160] https://qz.com/911968/bill-gates-the-robot-that-takes-your-job-should-pay-taxes/ Robert Shiller agrees: "It may be more politically acceptable... to tax the robots rather than just the high-income people." https://www.project-syndicate.org/commentary/temporary-robot-tax-finances-adjustment-by-robert-j--shiller-2017-03
[161] http://www.nakedcapitalism.com/2017/02/links-21817.html James Wordsworth's comment
[162] http://www.policy-network.net/pno_detail.aspx?ID=4728&title=Smart-and-inclusive-growth
[163] "Our robot computes its algorithm 67 times every second, constantly stitching together information about its environment and recomputing its path. When it starts you'll notice a spiral pattern, it'll spiral out over a larger and larger area until it hits an object. When it finds an object, it will follow along the edge of that object for a time, and then it will start criss-crossing, trying to figure out the largest distance it can go without hitting another object, and that's helping it figure out how large the space is, but if it goes for too long a period of time without hitting a wall, it's going to start spiraling again, because it figures it's in a wide open space, and it's constantly calculating and figuring that out. It's similar with the dirt sensors underneath, when one of those sensors gets tripped it changes its behaviors to cover that area. It will then go off in search of another dirty area in a straight path. The way that these different patterns pile on to each other as they go, we know that that is the most effective way to cover a room. The patterns that we chose and how the algorithm was originally developed was based off of behavior-based algorithms born out of MIT studying animals and how they go about searching areas for food." http://www.aiqus.com/forum/questions/13167/algorithm-that-irobots-roomba-uses
[164] https://www.scientificamerican.com/article/how-understanding-animals-can-help-us-maximize-artificial-intelligence/
[165]*The Second Machine Age*, pp. 233-4. Suppose the taxable point is set at $30,000. A person who earns $20,000 would be paid a negative tax on $10,000—say 50% of that.
[166] The Connection Between Work and Dignity Smith, Bloomberg 12/21/16 "....is there work to be done in the U.S. that produces tangible, visible value? Of course there is. To realize this, just take a one-week trip to Japan. Where American sidewalks are cracked and uneven, Japanese ones are neat and beautiful. Where tables in American Starbucks are littered with crumbs and dirt, Japanese Starbucks tables get wiped down after every customer leaves. Where American cities like Chicago and Detroit are full of broken windows and crumbling facades, Japanese cities are clean and modern, with well-maintained, reliable public transit...."